

# NAVAL POSTGRADUATE SCHOOL

## Monterey, California



**PEGASUS IN THE SEA OF CORTES AREA (PESCAR)**  
**Pegasus Data Report for PESCAR Cruises in**  
**April and December 1992**

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March 1995

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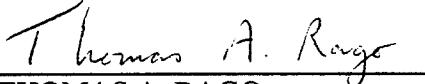
This report was funded by the Naval Postgraduate School under the sponsorship of the Commander, Naval Oceanography Command.

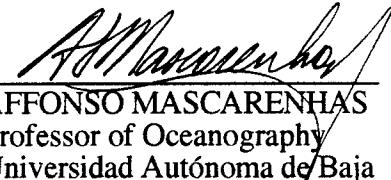
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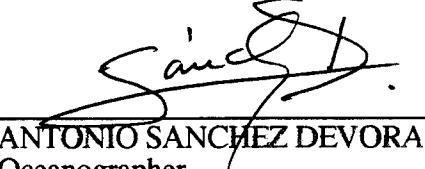
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## REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.

1. AGENCY USE ONLY ( <i>Leave blank</i> )			2. REPORT DATE 10 Mar 95	3. REPORT TYPE AND DATES COVERED Technical Report
4. TITLE AND SUBTITLE Pegasus in the Sea of Cortes Area (PESCAR) Pegasus Data Report for PESCAR cruises in April and December 1992			5. FUNDING NUMBERS	
6. AUTHORS Newell Garfield, Curtis A. Collins, Thomas A. Rago, Affonso Mascarenhas, and Antonio Sanchez-Devora				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Oceanography Department, Naval Postgraduate School, Monterey CA 93943-5122			8. PERFORMING ORGANIZATION REPORT NUMBER NPS-OC-95-001	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Commander, NMOC, Naval Meteorology Oceanography Command, Stennis Space Center, Bay St. Louis, MS			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES Joint project between the U.S. Navy, the Mexican Navy, and the Universidad Autonoma de Baja California (UABC).				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			12b. DISTRIBUTION CODE A	
13. ABSTRACT ( <i>maximum 200 words</i> ) Results of direct ocean current measurements at the entrance of the Gulf of California (Sea of Cortes) are presented. Velocity measurements were made using an acoustically-tracked dropsonde called Pegasus at six sites across the entrance to the Gulf. 49 Pegasus deployments were completed over the course of two oceanographic cruises in April 1992 and December 1992/January 1993. During each cruise two complete velocity transects were obtained, providing four independent realizations of the current structure. The data herein are presented by Pegasus deployment site as six sets of mean and individual velocity profiles.				
14. SUBJECT TERMS: U.S. Navy, Mexican Navy, Universidad Autonoma de Baja California, Sea of Cortes, Gulf of California, Pegasus, velocity profile, ocean currents, ocean transports.			15. NUMBER OF PAGES 103	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	

February 1995

Pegasus Data Report #1  
Department of Oceanography  
833 Dyer Road, Rm 331  
Naval Postgraduate School  
Monterey, California 93943-5112

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# PEGASUS IN THE SEA OF CORTES AREA (PESCAR)



## Pegasus Data Report for PESCAR cruises in April and December 1992

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# Pegasus in the Sea of Cortes Area (PESCAR): Pegasus Data Report for Cruises in April and December, 1992

## 1. Introduction

Direct measurements of ocean currents at the entrance to the Gulf of California were made from **USNS DeSteiguer**, April 20 - May 8, 1992 and **R/V Point Sur**, December 28, 1992 - January 8, 1993. Velocity measurements were made using an acoustically tracked dropsonde called Pegasus (Spain et al, 1981). Six Pegasus stations were established across the entrance to the Gulf of California to delineate the flow into and out of the Gulf (Figure 1). A number of compromises were necessary in choosing the locations for these stations. The Pegasus transection attempted to find a location where the local bathymetric contours were parallel to the direction of the Gulf. It was desirable that our survey would be synoptic and could be completed in four or five days. Since possible sections lay near Alarcon Seamount, the decision was made to pass our transection directly over the top of the Seamount, rather than trying to move the transection farther into the Gulf where the influence of the seamount on circulation might be less, but other bathymetric features would be encountered.

CTD data were also collected at 19 sites along this transection during both cruises. Rago et al. (1992) present the CTD data for the April 1992 cruise, and Spearman (1993) presents an analysis of the CTD data for both cruises as well as listing the data for the December 92 cruise.

## 1. Introducción

Se hicieron mediciones directas de corrientes oceánicas en la entrada del Golfo de California a bordo del buque **USNS DeSteiguer** del 20 de abril al 8 de mayo de 1992, y del 28 de diciembre al 8 de enero de 1993 abordo del **R/V Point Sur**. Las mediciones de velocidad fueron hechas mediante la sonda acústica denominada Pegasus (Spain et al. 1981). Seis estaciones de Pegasus fueron predeterminadas para la boca del Golfo de California con la finalidad de establecer el flujo de entrada y salida (Figura 1). Cierto número de compromisos tuvieron que hacerse al momento de escoger los lugares para hacer las estaciones. Los transectos de Pegasus fueron hechos con la idea de encontrar un lugar en donde el flujo estuviera restringido por el Golfo de tal manera que los contornos batimétricos cerca de las estaciones fueran paralelos a la dirección del Golfo. Lo deseable en nuestro estudio es que este fuera sinóptico y que fuera completado en cuatro o cinco días. En el caso de que ciertas secciones quedaran cerca o sobre el monte marino Alarcón se tomó la decisión de pasar los transectos directamente sobre el monte, en lugar de mover los transectos Golfo adentro, en donde la influencia del monte sobre la circulación fuera posiblemente menor, pero se encontrarían, otros tipos de estructuras batimétricas.

Se tomaron además datos de CTD en 19 localidades a lo largo del transecto en ambos cruceros. Rago et al. (1992) presentan los datos de CTD correspondientes a abril de 1992 y Spearman en (1993) analiza y presenta los datos de CTD de ambos cruceros además de proporcionar los listados de datos correspondientes al crucero de diciembre de 1992.

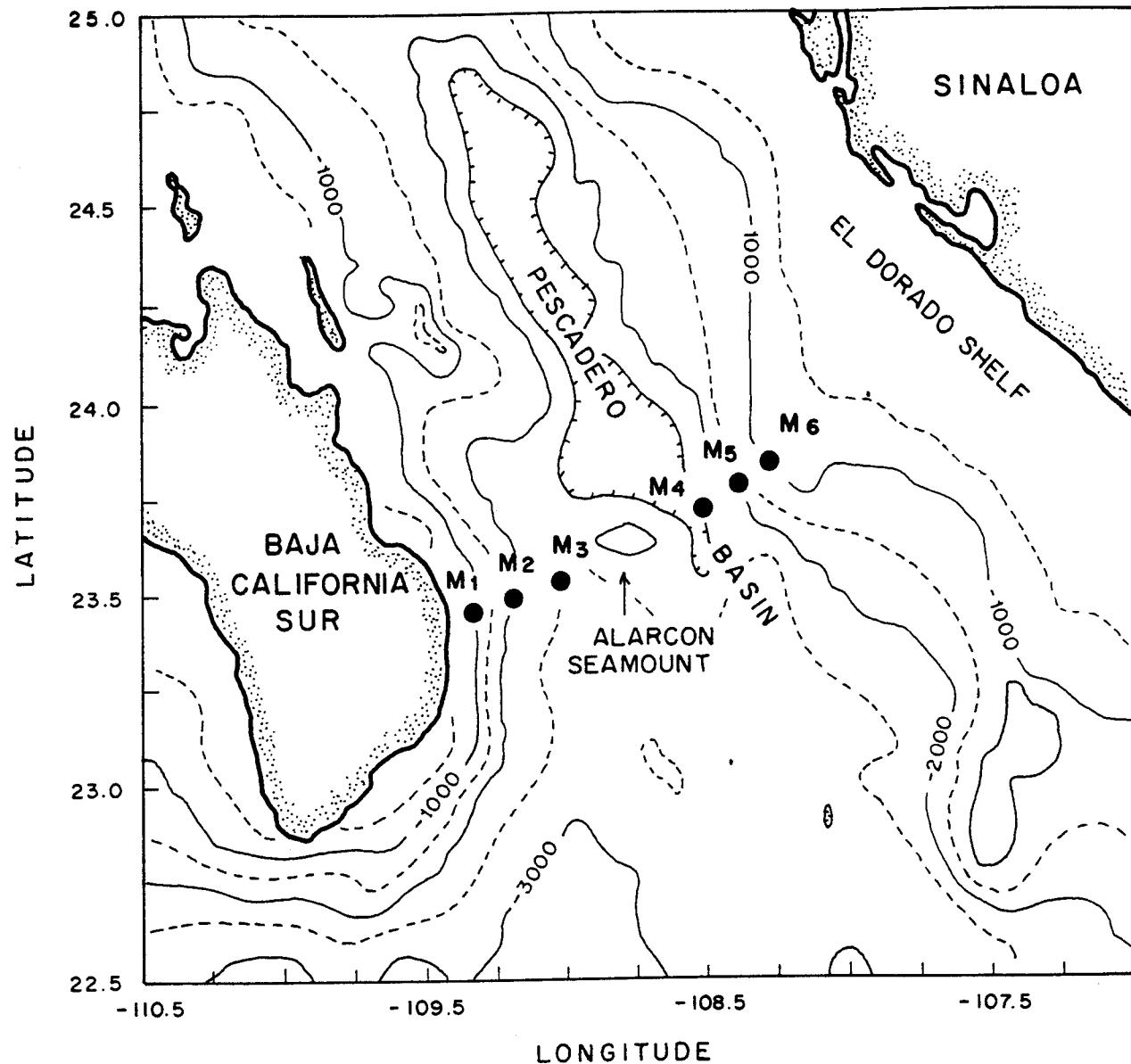


Figure 1. Station locations, M1-M6, at the entrance to the Gulf of California.

## 2. Data Acquisition and Processing

The design, deployment and initial navigation of the acoustic transponders at each site was done following the method of Spain et al. (1981). The horizontal distance between two transponders is called the baseline. At any site, the baseline distance should approximately equal the water depth. Experience has shown that when the baseline distances are less than about 1000 m, the navigational noise becomes significant. Thus, 1000 m is the minimum water depth for deploying transponder arrays. The NPS Pegasus Profiler Instrument (Benthos Model ES700-179, Serial Number 15) has the capability of receiving up to six transponders at a time. Navigation programs require a minimum of two transponders to locate the instrument, and additional transponders improve the quality of positioning, especially at depth (Haskell, 1991). But where transponder sites are located within 10-20 kilometers of one another, transponders of the same frequency at adjacent locations can occasionally respond to Pegasus, blocking out the desired transponder signal. Therefore, at each PESCAR site, named M1 to M6, three transponders were deployed in roughly an equilateral triangle.

The baseline length between the first two transponders was estimated by steaming along the intended baseline at a known speed and timing the interval between the release of the two transponders. Following deployment, an acoustic navigation survey was conducted. Using a precision time recorder, the ship was maneuvered directly overhead of each transponder to determine the deployment depth. Then the ship steamed along the bisector of the baseline to determine the slant range to each transponder. From the transponder depths and the slant ranges, the baseline length was determined. The orientation was determined by the course steered to bisect the baseline. During PESCAR cruises, GPS navigation was used, and

## 2. Adquisición y procesado de datos

El diseño, fondeo y ruta inicial de navegación establecidos para cada transmisor-respondedor = ( transceptor ) acústico en cada estación, fueron hechos de acuerdo al método de Spain et al. (1981). La distancia horizontal entre dos transceptores es denominada la línea base. En cualquier estación la longitud de esta línea base deberá ser aproximadamente igual a la profundidad del lugar. La experiencia ha demostrado que cuando la línea base es menor que 1000 m, el ruido navegacional es significativo. Por lo tanto 1000 m es la profundidad mínima requerida para fondear arreglos de transceptores. El perfilador Pegasus de la Naval Postgraduate School (NPS), (Benthos modelo ES700-179, número de serie 15) tiene la capacidad de recibir hasta seis señales acústicas a la vez. Los programas de navegación requieren de un mínimo de dos transceptores para poder localizar el instrumento. Más de dos transceptores mejoran la calidad del posicionamiento, especialmente con respecto a la profundidad (Haskell, 1991). En sitios en donde los transceptores se encuentren a una distancia de entre 10-20 kilómetros uno de otro, transceptores de la misma frecuencia, pueden ocasionalmente obstaculizar la señal del transceptor deseada. Por tal razón para las estaciones M1 a M6 del crucero PESCAR hubo de fondearse tres transceptores formando una triángulo equilátero entre ellos.

La longitud de la línea base entre los dos primeros transceptores fué estimada navegando sobre la línea base planeada previamente, a una velocidad conocida y mediendo el intervalo de tiempo entre el lanzamiento de los dos transceptores. Despues de fondearlos se realizó una navegación acústica directamente sobre los transceptores recién fondeados con la finalidad de determinar la profundidad a

the deployment location of the third transponder was done using the GPS release locations of the first two transponders. An acoustic survey was then conducted on each of the three baselines.

Post cruise transponder navigation was done using a modification of the technique presented by Haskell (1991) and reported by Garfield et al. (1994). Data from a number of drops are assembled and processed using a least squares algorithm to refine the transponder locations and provide error estimates. The technique is similar to survey techniques of Hunt, et al. (1974) and Luyten et al. (1982), except that data from throughout the water column are used instead of only surface values. At sites M1 through M5, the adjustments were within the expected error of the ship-based navigation results (<5%). At M6 the least squares technique adjusted the transponder depths by 5 - 15%, and the baseline lengths by 2 - 4%. The least squares determined geometry did not lead to position and velocity estimates for each Pegasus drop, and hence the ship-based navigation was used for processing data from M6.

The suite of programs used to estimate the water column distribution of horizontal velocity from acoustic ranging on bottom mounted acoustic transponders originated at WHOI (Luyten et al., 1982) to navigate the White Horse acoustic dropsonde. The programs were modified at the University of Hawaii for the PEQUOD Line Islands experiment (1982-1983) (Firing, personal communication). The programs were further modified at NPS to run on a different computer, include the increased capabilities of the NPS Pegasus instrument, and use coincident CTD data to determine the local sound profile. Position determination of each record is accomplished by the geometric solution from the acoustic travel time to three transponders. When only two acoustic travel times are available, the position is determined using the two

la que quedaron fondeados. Luego la embarcación navegó sobre la mediatrix de la línea base para estimar la distancia a cada transceptor. Con las profundidades y las distancias a los transceptores se determinó la longitud de la línea base. Durante los cruceros PESCAR se utilizó el sistema GPS, y la posición en donde se fondeó el tercer transceptor fué estimada utilizando la posición GPS, de los sitios en donde se liberaron los dos primeros transceptores. Finalmente se realizó sobre las tres líneas base un sondeo acústico.

Posterior al fondeo de los transceptores, fué realizada otro crucero de navegación sobre los transceptores utilizando una modificación de la técnica presentada por Haskell (1991) y reportada por Garfield et al. (1994). Datos de un cierto número de lances son ensamblados y procesados usando un algoritmo de mínimos cuadrados para refinar la posición de los transceptores y proporcionar estimaciones de los errores. La técnica es similar a las técnicas de reconocimiento de Hunt, et al. (1974) y Luyten et al. (1982), excepto que los datos utilizados son los de toda la columna de agua en lugar de solamente los valores superficiales. En las estaciones M1 a M5 los ajustes hechos estuvieron dentro del error esperado, basado en los resultados obtenidos de la navegación del barco (<5%). En la estación M6 se aplicó el método de mínimos cuadrados, para se ajustar las profundidades de los transceptores del 5-15% y las longitudes de la linea base de 2-4%. Debido a problemas instrumentales la geometría determinada por el método de mínimos cuadrados no fue utilizada para a estimar la posición y velocidad para cada lance de Pegasus y por esto , la navegación del buque fué utilizada para procesar los datos de la posición M6.

El conjunto de programas usados para estimar la distribución horizontal de velocidades en la columna de agua mediante los transceptores previamente colocados en el fondo del Golfo, fueron

travel times and the recorded pressure depth of the instrument. No position can be determined with only one acoustic travel time. Horizontal velocities are determined by differencing adjacent positions. Navigational accuracy was similar to that reported by Luyten et al. (1982), with resulting velocity errors of 2-4 cm/s over 20-m intervals. Navigational accuracy varies inversely with the vertical averaging interval.

The Pegasus instrument was programmed to determine acoustic travel time every 16 seconds. Typical descent and ascent rates of 0.5 m/s resulted in an average vertical resolution of ~8 m. Pegasus was equipped with a bottom-release mechanism for the ballast used to sink the instrument. Thus, for each deployment, two top-to-bottom profiles were obtained, one during the descent, and one during the ascent. The two output files for each Pegasus deployment contain a profile of the u and v velocity components for each sampling period (depth). Where no velocity values were determined, a data flag was placed in the velocity field.

Experience has shown that inertial oscillations sometimes dominate velocity profiles. To average out these effects two deployments were made at each site, separated in time by one half an inertial period (about 30 hours for these latitudes). During both the April and December cruises, the Pegasus transection was sampled on each of two legs. Thus the transection was occupied four times, with a total of eight drops and 16 profiles collected at each site. Three drops were collected together twice, once at M4 and once at M6. Acoustic tracking failed at M5 on the first leg of the April cruise.

desarrollados en WHOI (Luyten et al., 1982) y fueron hechos para operar la sonda acústica White Horse. Los programas fueron modificados en la universidad de Hawái para el experimento PEQUOD de las islas Líne (1982-1983) (Firing, comunicación personal). Los programas fueron nuevamente modificados en la NPS para correr en otro tipo de computadora, incluyendo las nuevas capacidades de la sonda acústica Pegasus de la NPS además se utilizar datos coincidentes de CTD para determinar el perfil local de sonido. La determinación de la posición de cada registro fué hecha mediante la solución geométrica de acuerdo al tiempo de viaje de la onda acústica hacia los tres transceptores. En los casos en donde solo estan disponibles dos tiempos de viaje de la onda acústica la posición se determina usando los tiempos de viaje de cada transceptor y el registro de presión a profundidad del instrumento. No se puede determinar la posición con solo un valor de tiempo de propagación acústica. Las velocidades horizontales son determinadas por diferenciación de posiciones adyacentes. La exactitud de la navegación fué muy similar a la reportada por Luyten et al. (1982) con errores resultantes para las velocidades entre 2-4 cm/s en intervalos de 20 m. La exactitud navegacional varia inversamente con el intervalo promediado vertical.

La sonda Pegasus fue programada para determinar el tiempo de viaje acústico cada 16 s. Con razones de ascenso-descenso típicas del orden de 0.5 m/s. resultó en una resolución vertical promedio de ~8 m. La sonda Pegasus esta equipada con un mecanismo liberador de fondo para deshacerse del peso muerto usado para hundirlo. Así para cada lanzamiento se obtiene dos perfiles de la superficie hasta el fondo, uno durante el descenso y otro durante el ascenso. Los dos archivos de salida para cada lanzamiento de Pegasus contienen el perfil de velocidades u y v para cada periodo de muestreo (profundidad). Donde no se determinaron valores de

### **3. Data Presentation**

Table 1 lists the date, time, and launch position for each Pegasus sounding as well as the resultant displacement or transport and the mean velocity. Data are then presented for each of the six sites, M1 through M6. A chart of the transponder and launch positions is included as is a chart of the transport results. Mean velocity profiles from each leg are presented as are individual velocity profiles. The velocity profiles have been assembled by first interpolating the output of the navigation program into a file that had 10 m depth increments down to 300 m and then 25 m increments to the bottom. Interpolation was only done if the bounding velocity measurements for a given depth were separated vertically by less than 30 m (about four records of data). If the interpolation distance were greater than 30 m, a no-data flag was placed in the interpolated field. The mean velocity was computed as the mean if there were two or more data points available at the depth, and the standard deviation was determined. If only one good velocity was recorded, that value was used as the mean, and the standard deviation flagged as no data. Where no data were available at a depth, both the mean and standard deviation fields were flagged as no data. The first figure for each pair of drops shows the four profiles. The second figure shows the mean  $u$  and  $v$  velocity components along with  $\pm$  one standard deviation. Where only one velocity value was available, no standard deviation range is plotted.

### **4. Acknowledgements**

Mexican participation in this program has been supported by Consejo Nacional de Ciencia y Tecnología through grant 1076-T9201 and Secretaría de Marina. U.S. participation has been supported by the Naval Postgraduate School and the Oceanographer of the Navy. The enthusiastic and capable support of the masters and crews of the

velocidad, se coloca una señal indicadora en el campo de velocidad. La experiencia ha demostrado que las oscilaciones inerciales en algunos casos dominan el perfil de velocidades. Con el fin de disminuir este efecto se hacen dos lances en cada estación separados en tiempo por lo menos la mitad del periodo inercial, cerca de 30 horas para estas latitudes. Durante los cruceros de abril y diciembre, los transectos de Pegasus fueron muestrados dos veces, una de ida y otra de regreso. Así el transecto fué ocupado cuatro veces contabilizando un total de 8 lances y 16 perfiles en cada estación. Tres lances fueron colectados juntos dos veces, una vez en M4 otra vez en M6. En la estación M5 no se pudo seguir la pista acústica de Pegasus en la primera sección del crucero de abril.

### **3. Presentación de los datos**

En la tabla 1 se presenta una lista de las fechas, hora y posición de lanzamiento de la sonda Pegasus, así como el desplazamiento resultante o transporte y la velocidad media. Se presentan los datos para cada seis localidades de la M1 a la M6. Una carta de las posiciones de los transceptores y de las posiciones de lanzamiento se incluyen así como una carta con los resultados del transporte. Los perfiles de velocidad media para cada sección son presentados así como los perfiles individuales. Los perfiles de velocidad han sido ensamblados, primero interpolando la salida del programa de navegación en un archivo que tiene incrementos de 10 m hasta 300 m y luego incrementos de 25 m hasta el fondo. La interpolación se hizo solamente si los registros existentes de velocidad para cada profundidad estuvieran separados verticalmente por menos de 30 m (más o menos cuatro registros de datos). Si la distancia de interpolación fuera mayor de 30 m una señal con el rotulo "no hay dato" es colocada en el campo de velocidades interpolado. La velocidad media fué calculada como promedio si existen dos datos o más a la profundidad, además

**USNS DeSteiguer and R/V Point Sur**  
are also gratefully acknowledged.

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Spearman, Monty G. (1993). Water masses and the thermohaline circulation at the entrance to the Gulf of California. Naval Postgraduate School, Monterey, CA. Masters Thesis, 190 pp.

de estimarse la desviación estandar. Si solo se grabó un dato bueno de velocidad este valor es tomado como el promedio, y se señala la desviación estandar como "no datos". En las profundidades donde no hay datos, el señal de que no hay valor medio y desviación estandar es utilizada. La primera figura para cada par de lances muestra los cuatro perfiles. La segunda figura muestra las componentes medias de velocidad  $u$  y  $v$  con su desviación estandar. En donde solo un valor de velocidad estuvo disponible, no se graficó ningún intervalo de desviación estandar.

## 4. Agradecimientos

Se agradece al Consejo Nacional de Ciencia y Tecnología por el apoyo al proyecto de investigación (1076-T9201) así como a la Secretaría de Marina. Los fondos necesarios para la participación de los científicos de los Estados Unidos de América fue proporcionada por la Escuela Naval de Postgraduados y los oceanógrafos de la marina de los E.U. (Navy). Se agradece además el entusiasta apoyo brindado tanto por los oficiales como la marinería de las embarcaciones **USNS DeSteiguer** y **R/V Point Sur**, respectivamente.

Drop	Station	Depth	Launch			Date	Time GMT	Transport		
			Latitude	Longitude	Direction degrees			speed cm/s	volume m³/s	
413	3	2633	23.546	109.020	25-Apr	4:16	187	13.3	351	
414	2	2242	23.491	109.175	25-Apr	9:07	209	07.8	175	
415	1	1087	23.463	109.338	25-Apr	13:41	176	10.4	113	
421	3	2618	23.550	109.047	25-Apr	20:43	188	09.1	237	
422	2	2251	23.490	109.176	26-Apr	1:26	217	04.8	108	
423	1	1135	23.462	109.337	26-Apr	5:38	178	17.3	196	
424	4	2772	23.671	108.609	26-Apr	19:56	335	10.8	300	
425	5	2860	23.741	108.470	27-Apr	3:45	335	05.9	167	
426	6	892	23.817	108.310	27-Apr	9:12	030	05.0	045	
428	4	2673	23.668	108.607	27-Apr	14:04	335	10.2	273	
429	4	2757	23.666	108.608	27-Apr	17:54	339	09.0	249	
430	6	974	23.817	108.318	28-Apr	0:19	006	05.5	054	
431	6	1053	23.813	108.325	28-Apr	2:03	070	02.9	030	
432	6	952	23.816	108.317	2-May	9:01	028	03.6	034	
433	5	2808	23.741	108.462	2-May	17:23	347	07.6	212	
434	4	2758	23.667	108.601	3-May	0:27	340	07.8	216	
435	5	2808	23.741	108.460	3-May	8:03	022	03.8	107	
436	6	978	23.817	108.318	3-May	12:42	000	06.3	062	
437	4	2765	23.669	108.599	3-May	16:50	336	12.6	349	
438	3	2626	23.559	109.021	4-May	4:23	202	14.8	388	
439	2	2225	23.489	109.170	4-May	9:21	190	13.1	291	
440	1	1139	23.473	109.334	4-May	14:50	192	05.9	067	
441	3	2623	23.556	109.023	4-May	20:30	185	12.8	335	
442	2	2242	23.490	109.174	5-May	2:00	194	11.6	259	
443	1	1114	23.473	109.336	5-May	5:46	193	07.7	086	
444	1	1144	23.473	109.334	29-Dec	10:54	157	10.1	115	
445	1	1148	23.473	109.333	30-Dec	1:03	157	12.2	140	
446	2	2230	23.488	109.171	30-Dec	3:35	189	04.6	102	
447	3	2623	23.545	109.032	30-Dec	7:35	262	03.3	088	
448	2	2227	23.487	109.172	30-Dec	20:16	200	04.0	090	
449	3	2624	23.544	109.033	31-Dec	0:10	216	04.1	108	
450	4	2752	23.669	108.601	31-Dec	6:34	270	09.2	252	
451	5	2849	23.742	108.465	31-Dec	11:20	273	07.3	207	
452	4	2767	23.677	108.612	1-Jan	1:03	271	09.7	267	
453	5	2841	23.739	108.462	1-Jan	6:04	265	05.9	168	
454	6	1039	23.814	108.323	1-Jan	11:39	293	09.3	097	
455	6	1031	23.814	108.324	2-Jan	3:13	300	10.8	112	
456	3	2624	23.545	109.032	4-Jan	20:26	206	10.4	272	
457	2	2230	23.488	109.168	5-Jan	1:40	197	06.2	138	
458	1	1138	23.473	109.334	5-Jan	5:27	173	13.3	151	
459	3	2623	23.545	109.033	5-Jan	9:02	207	11.5	301	
460	2	2227	23.490	109.170	5-Jan	13:12	189	10.2	226	
461	1	1133	23.473	109.335	5-Jan	17:00	177	17.9	203	
462	4	2726	23.676	108.613	6-Jan	0:02	308	09.3	255	
463	5	2817	23.740	108.461	6-Jan	3:33	314	02.1	059	
464	6	1042	23.813	108.323	6-Jan	7:59	294	09.1	095	
465	6	992	23.812	108.320	6-Jan	22:36	295	08.1	080	
466	5	2821	23.740	108.460	7-Jan	0:57	266	02.0	056	
467	4	2773	23.676	108.612	7-Jan	5:12	303	11.3	313	

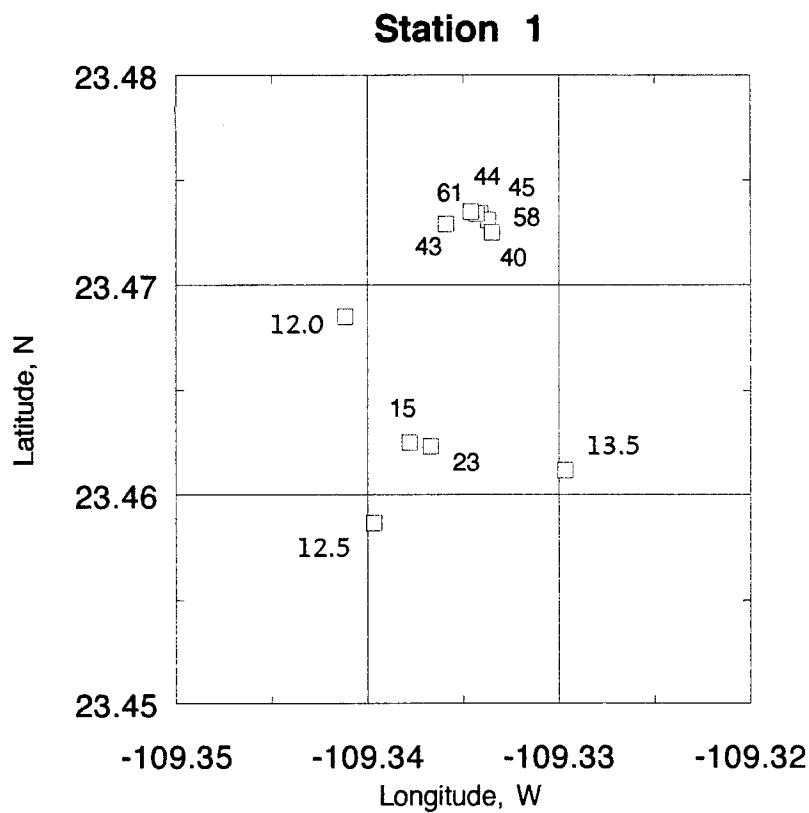


Figure M1-1. Pegasus launch and transponder positions at station M1. Transponders are identified by their reply frequency (12.0, 12.5 and 13.5 kHz) and launch positions are identified by the last two digits of the drop number given in Table 1.

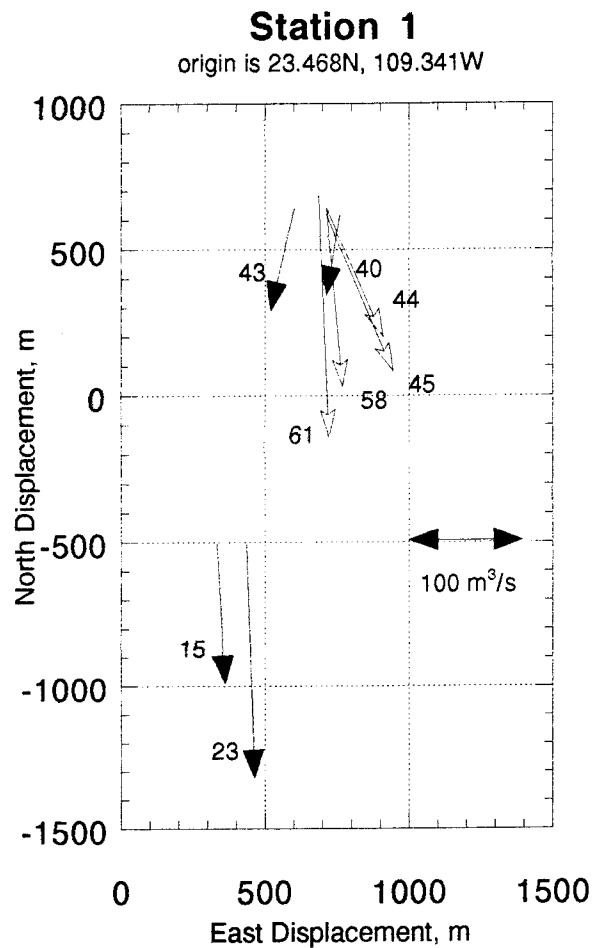


Figure M1-2. Transport measurements at station M1. Vectors connect the launch and surfacing position of Pegasus. The two digit numbers next to the vectors are the last two digits of the drop number given in Table 1. Solid arrow heads indicate observations made during the cruise which began in April 1992 and open arrow heads indicate observations made during the cruise which began in December 1992. Transport values assume a one square meter column of water with a thickness equal to the water depth.

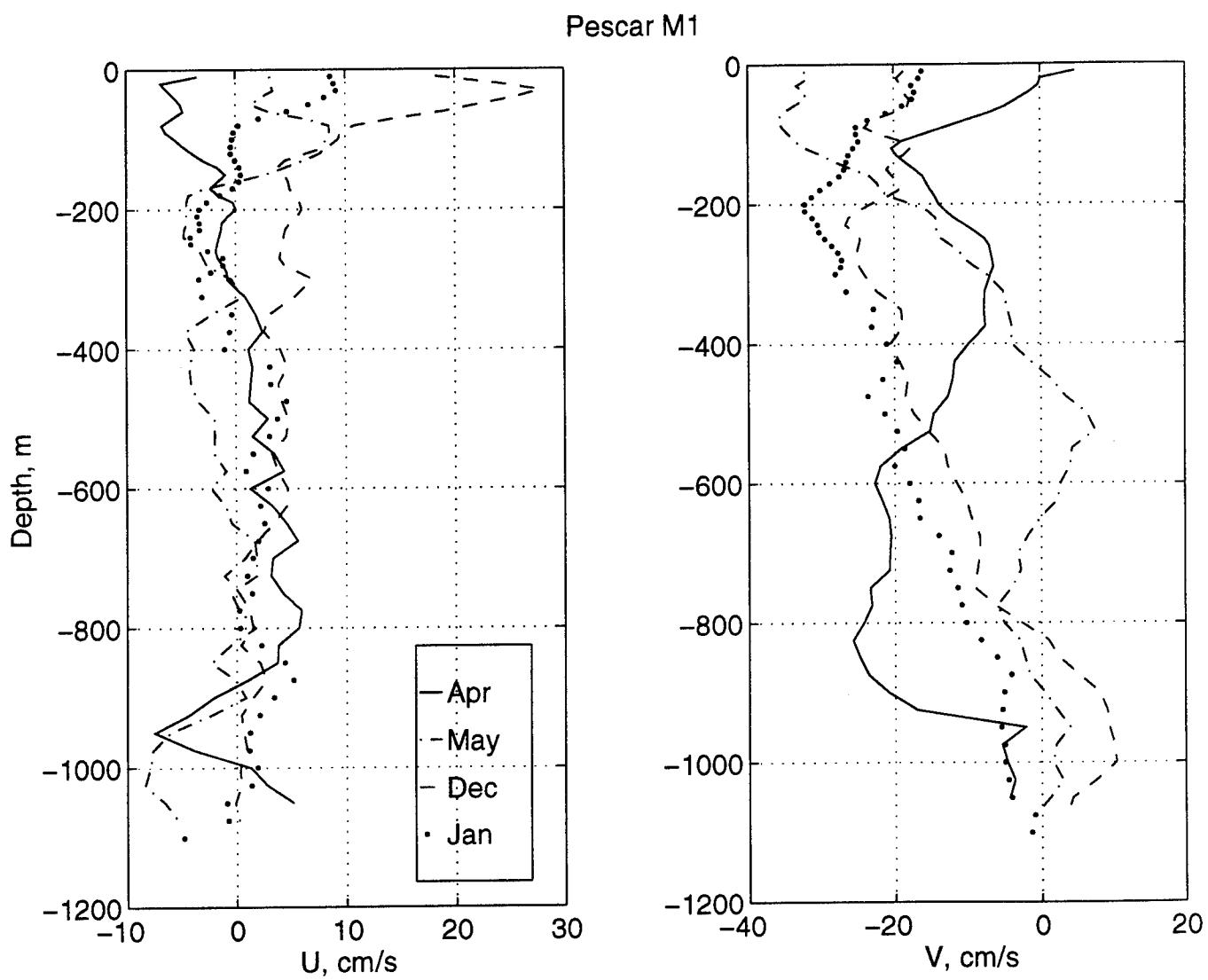


Figure M1-3. Mean velocity profiles at station M1 for each cruise leg. Left panel: East-west velocity component. Right panel: North-south velocity component.

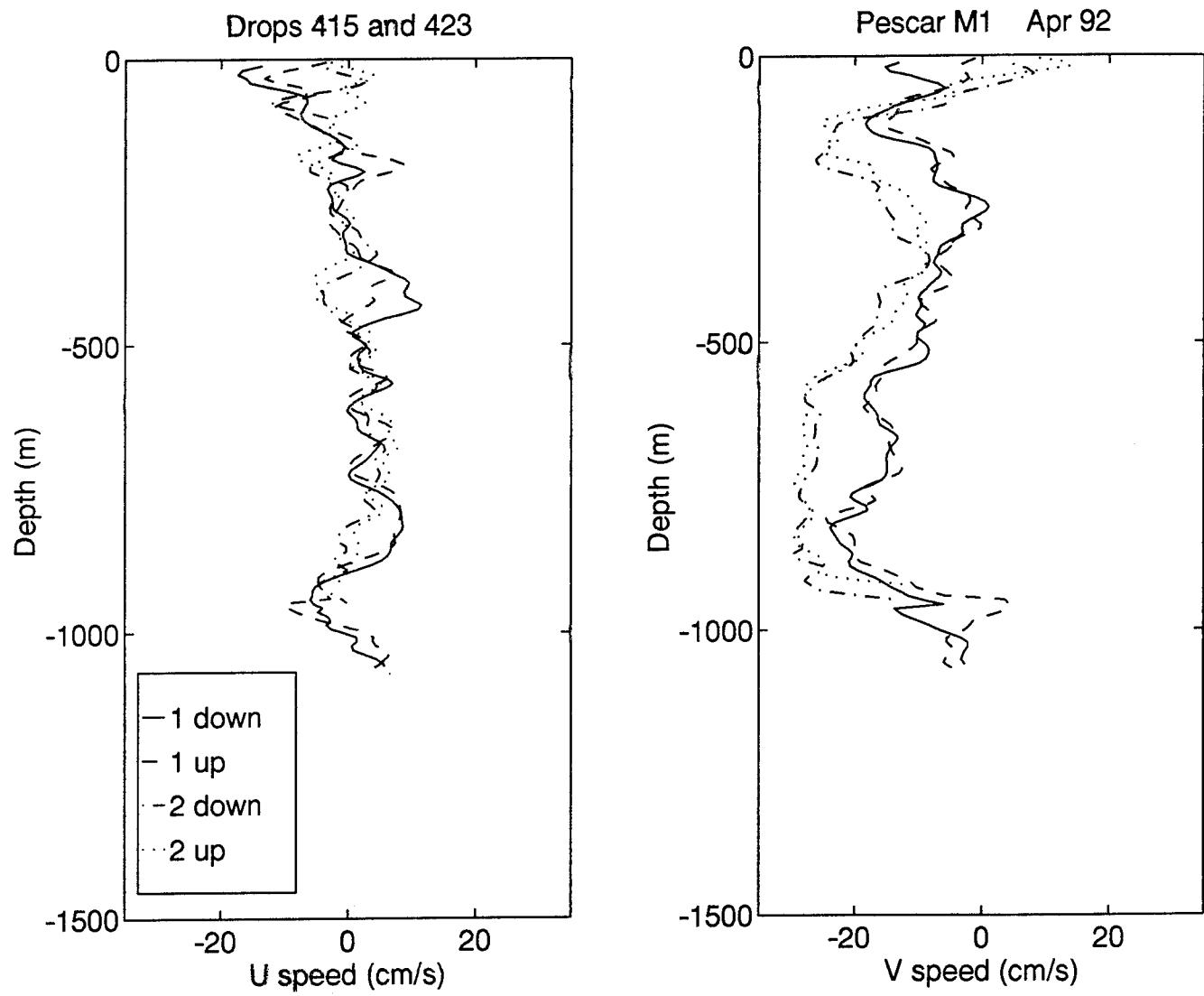


Figure M1-4. Velocity profiles at station M1 for Pegasus drops 415 and 423. Left panel: East-west velocity component. Right panel: North-south velocity component.

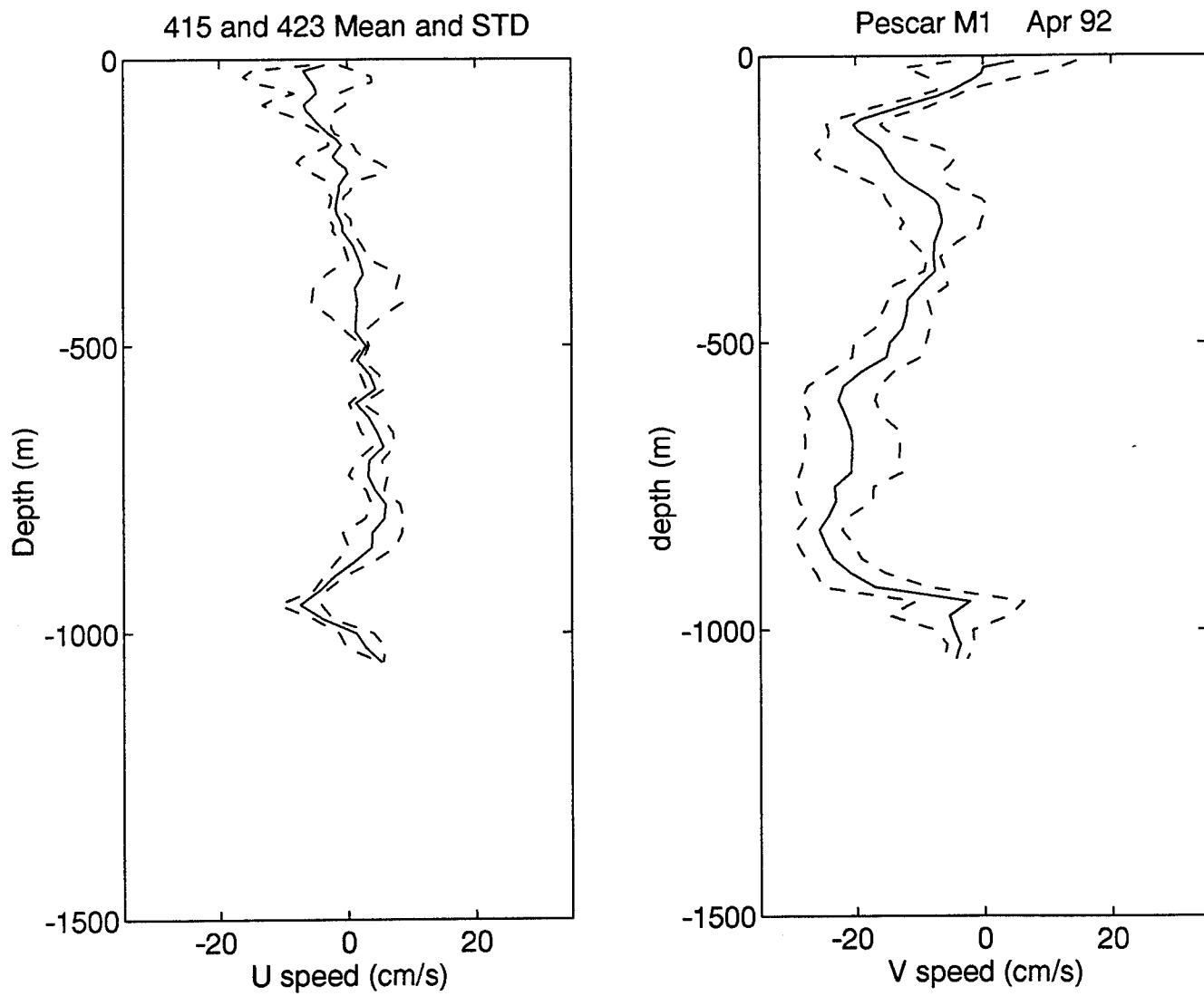


Figure M1-4 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

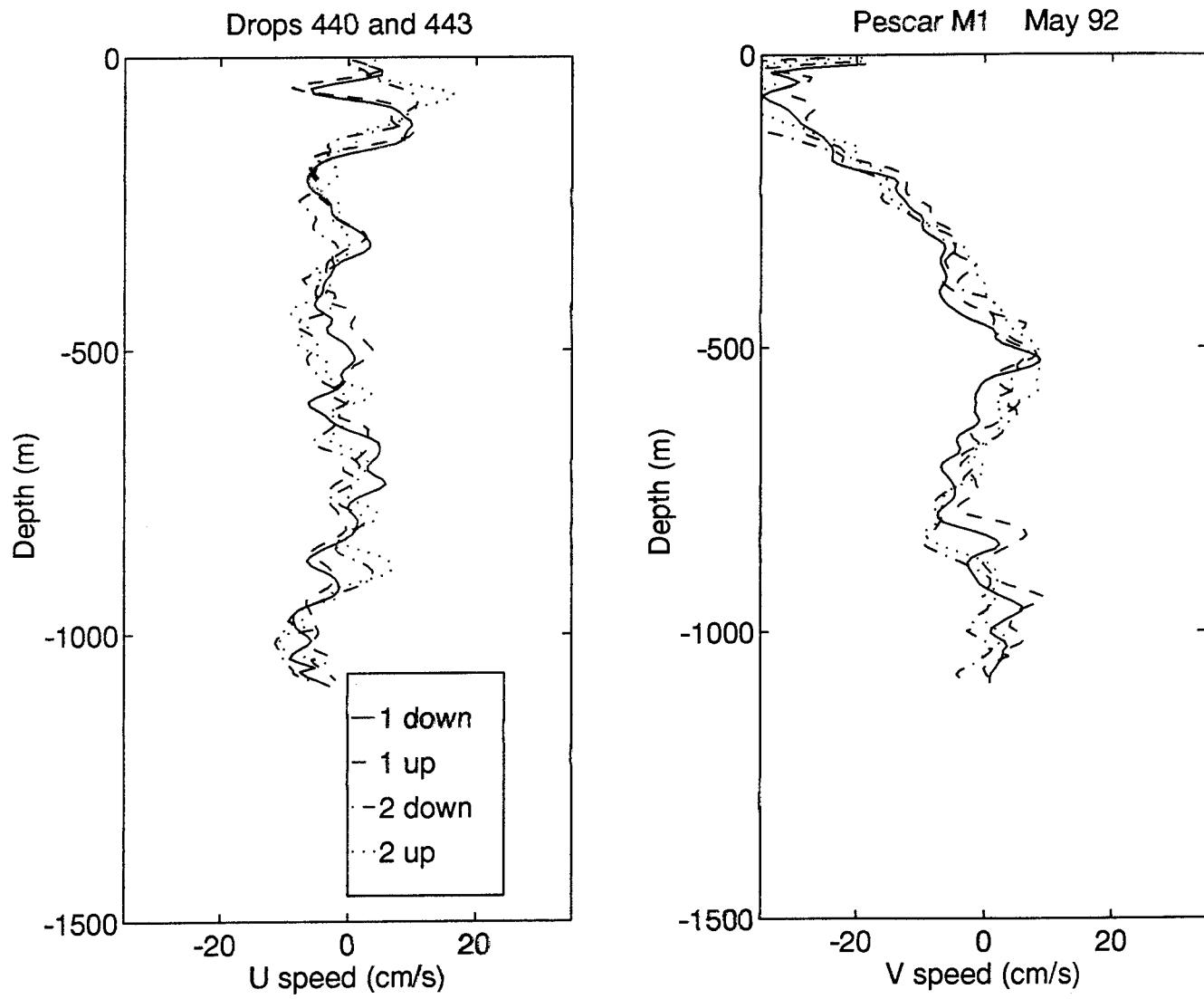


Figure M1-5. Velocity profiles at station M1 for Pegasus drops 440 and 443. Left panel: East-west velocity component. Right panel: North-south velocity component.

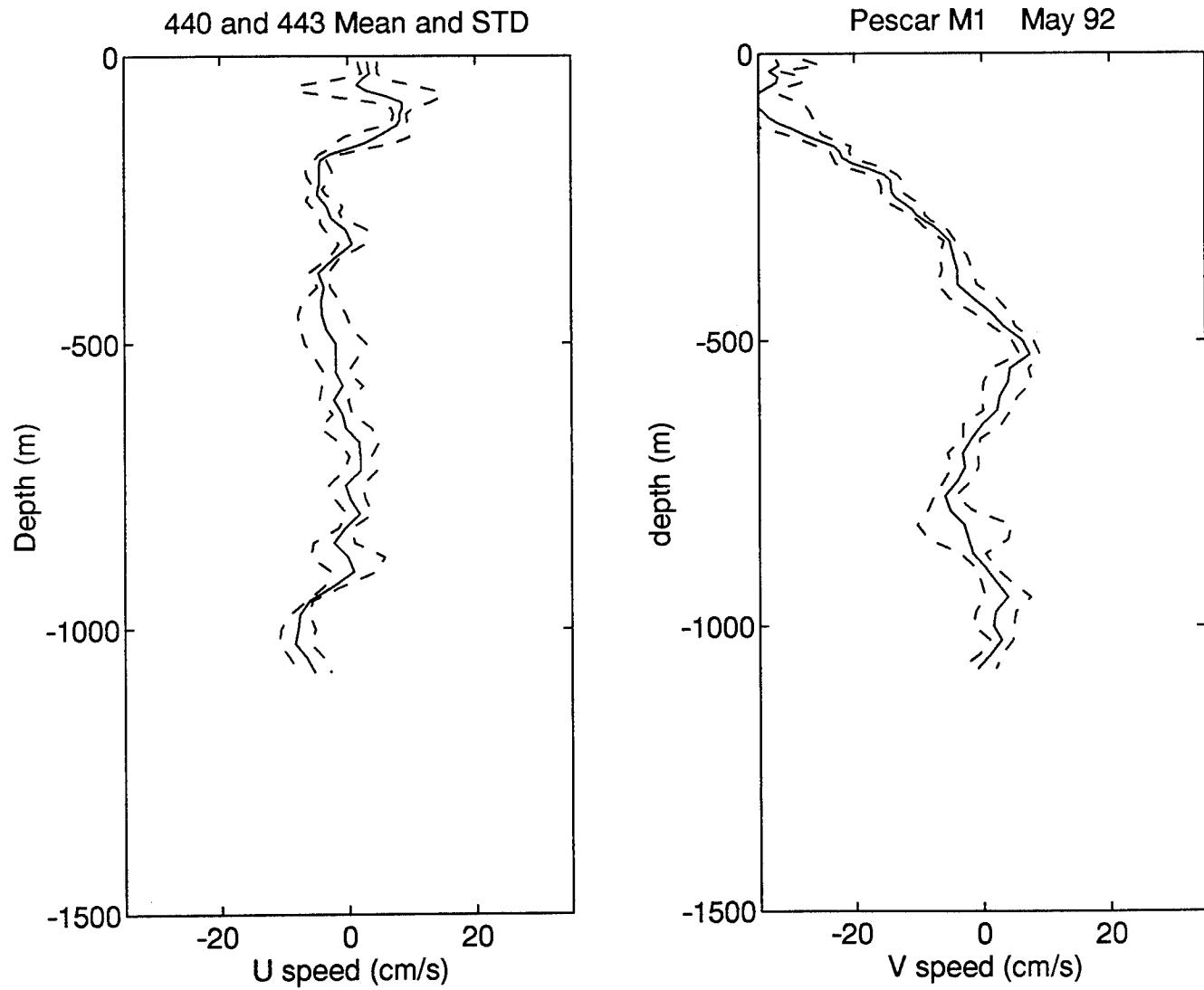


Figure M1-5 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

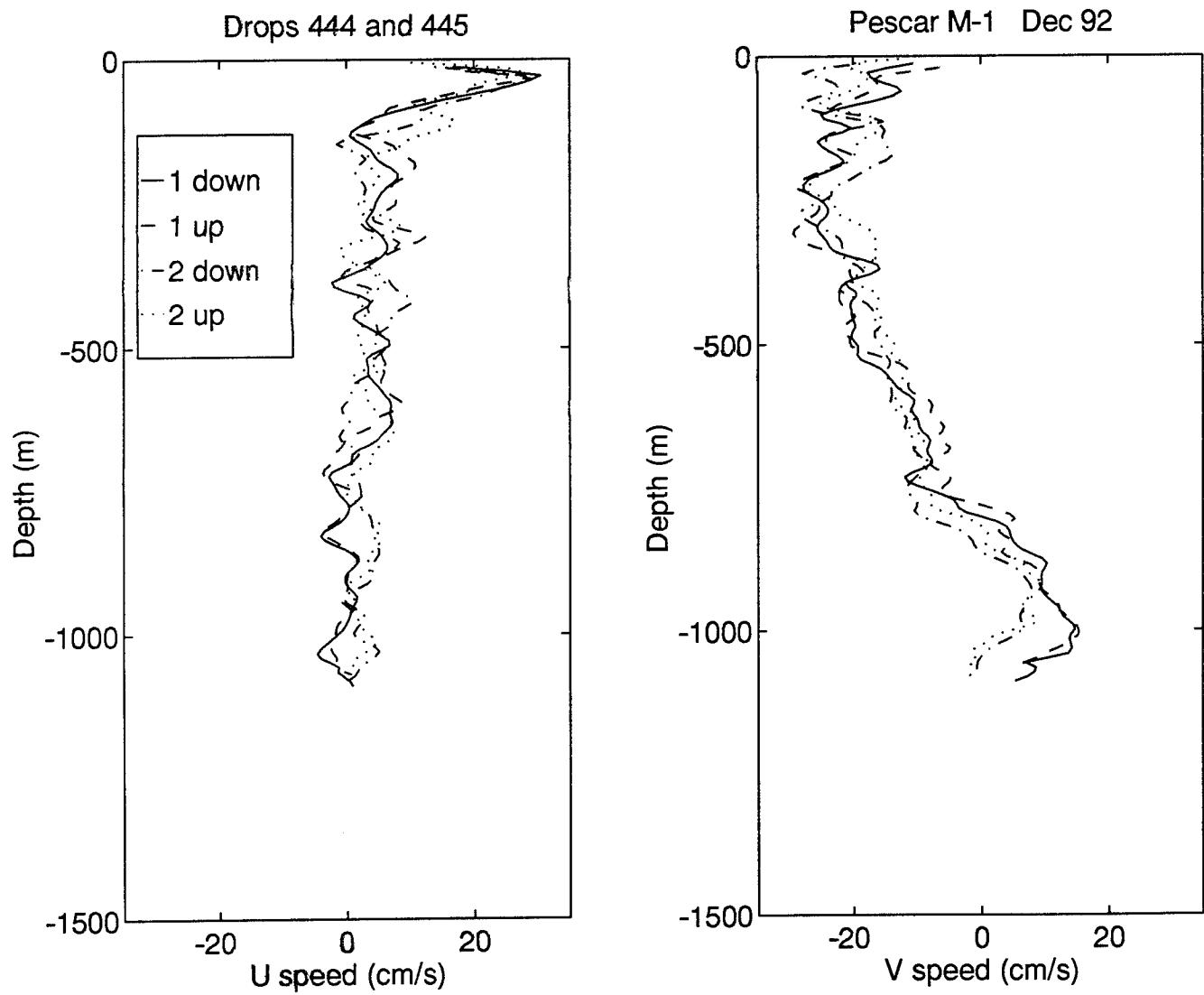


Figure M1-6. Velocity profiles at station M1 for Pegasus drops 444 and 445. Left panel: East-west velocity component. Right panel: North-south velocity component.

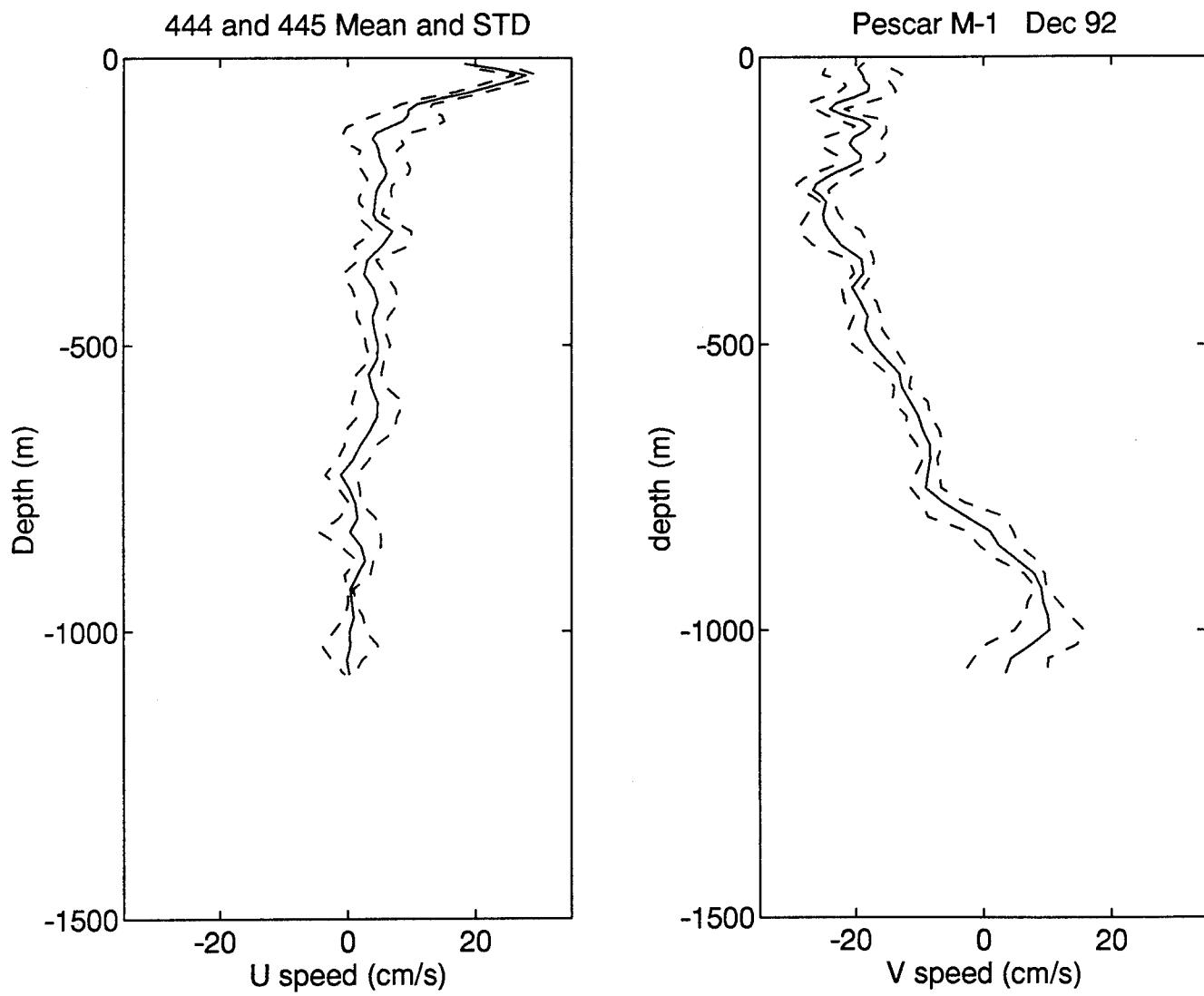


Figure M1-6 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

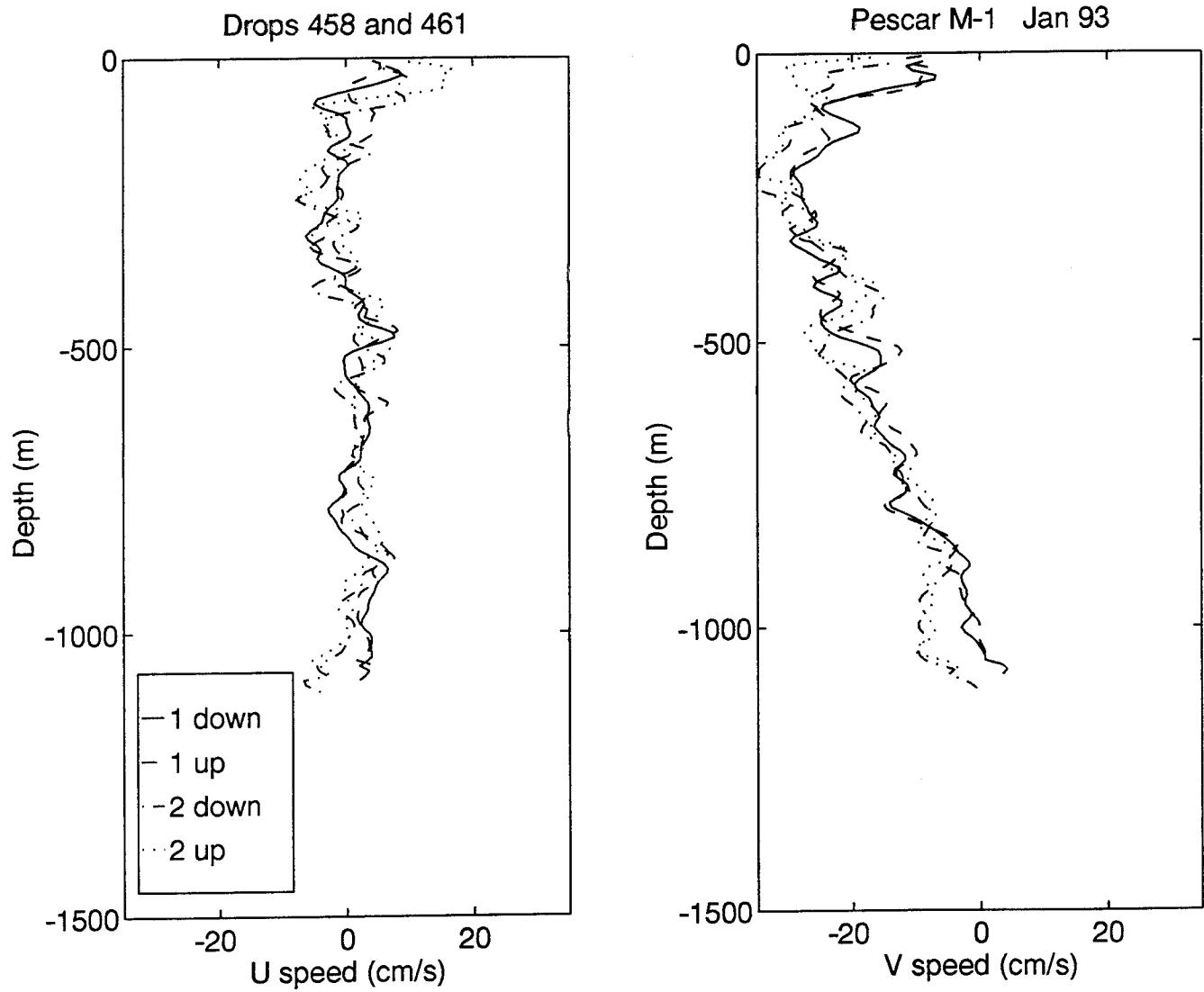


Figure M1-7. Velocity profiles at station M1 for Pegasus drops 458 and 461. Left panel: East-west velocity component. Right panel: North-south velocity component.

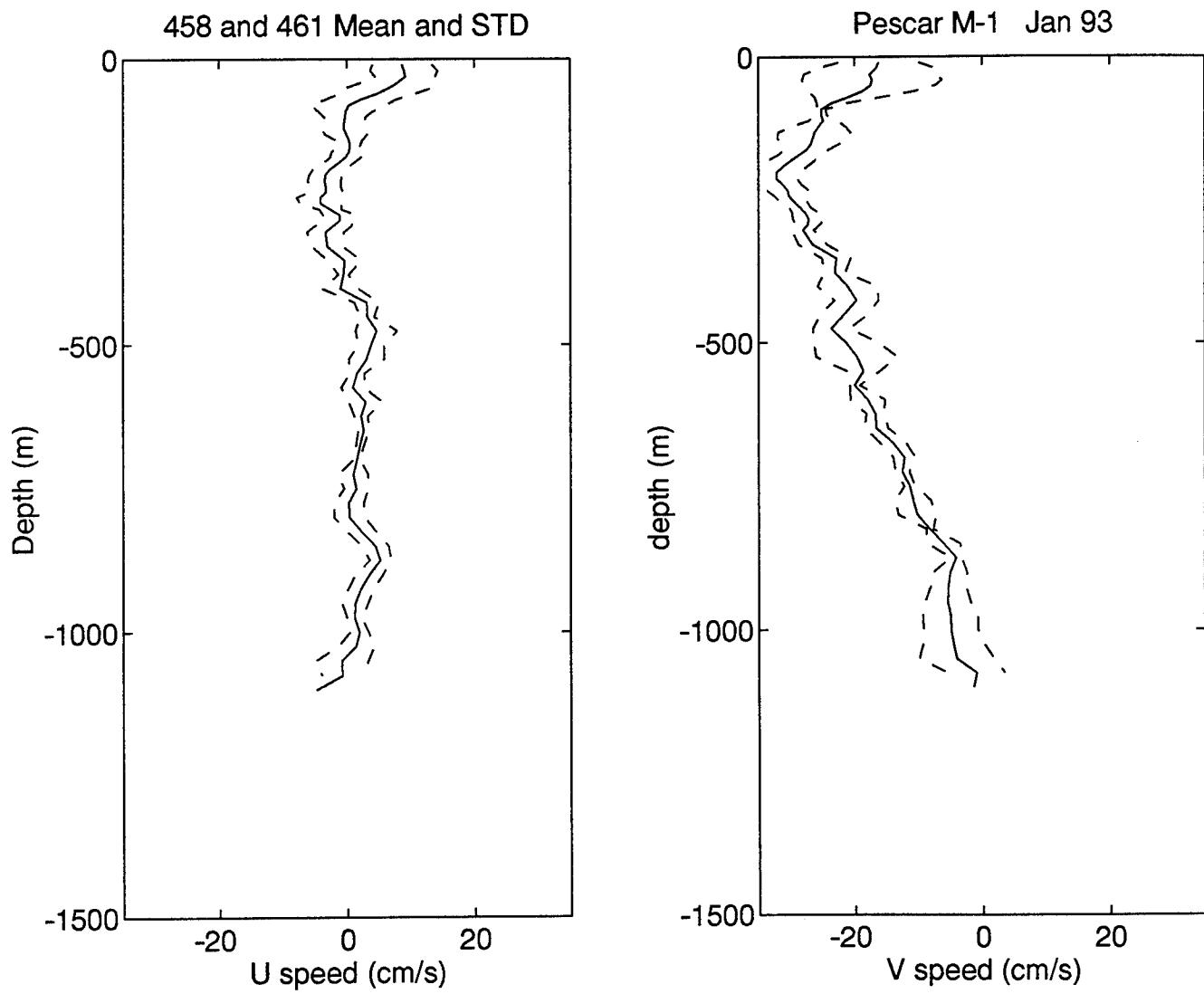


Figure M1-7 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

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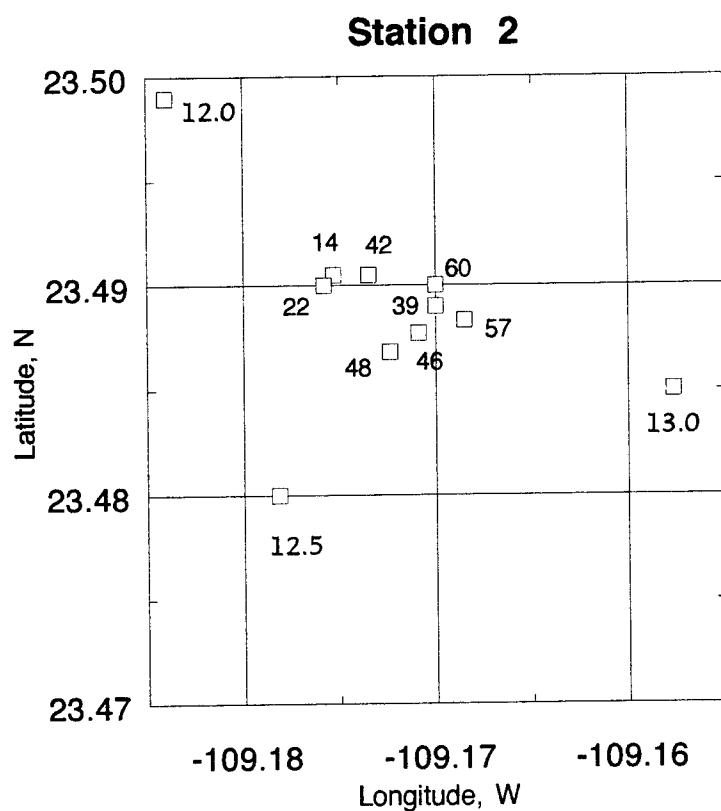


Figure M2-1. Pegasus launch and transponder positions at station M2. Transponders are identified by their reply frequency (12.0, 12.5 and 13.0 kHz) and launch positions are identified by the last two digits of the drop number given in Table 1.

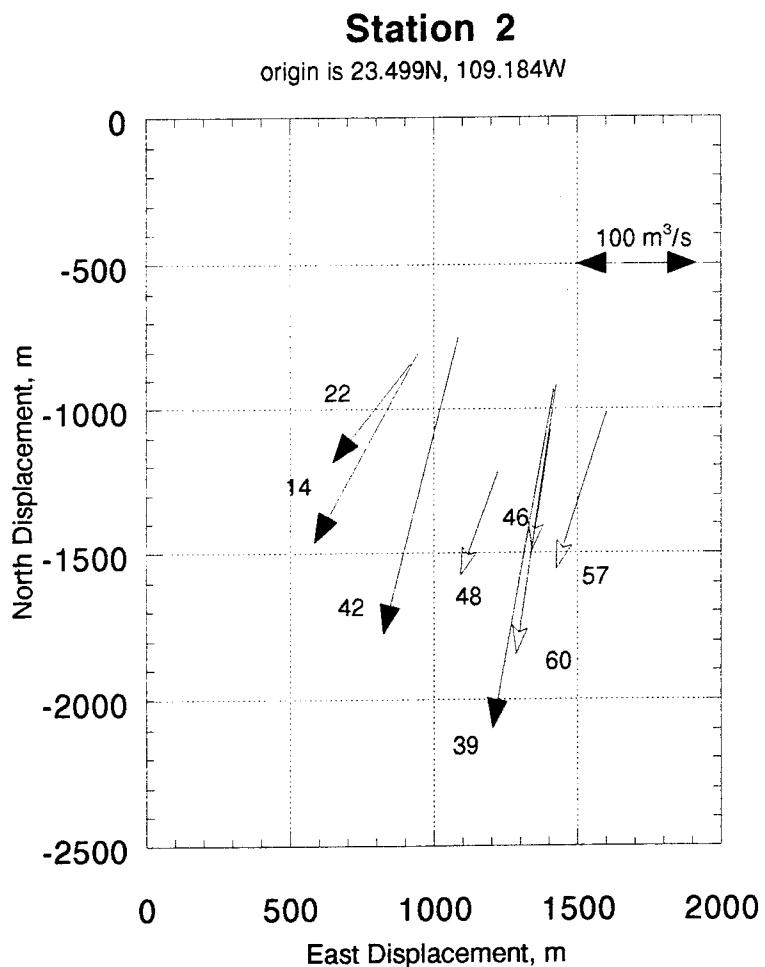


Figure M2-2. Transport measurements at station M2. Vectors connect the launch and surfacing position of Pegasus. The two digit numbers next to the vectors are the last two digits of the drop number given in Table 1. Solid arrow heads indicate observations made during the cruise which began in April 1992 and open arrow heads indicate observations made during the cruise which began in December 1992. Transport values assume a one square meter column of water with a thickness equal to the water depth.

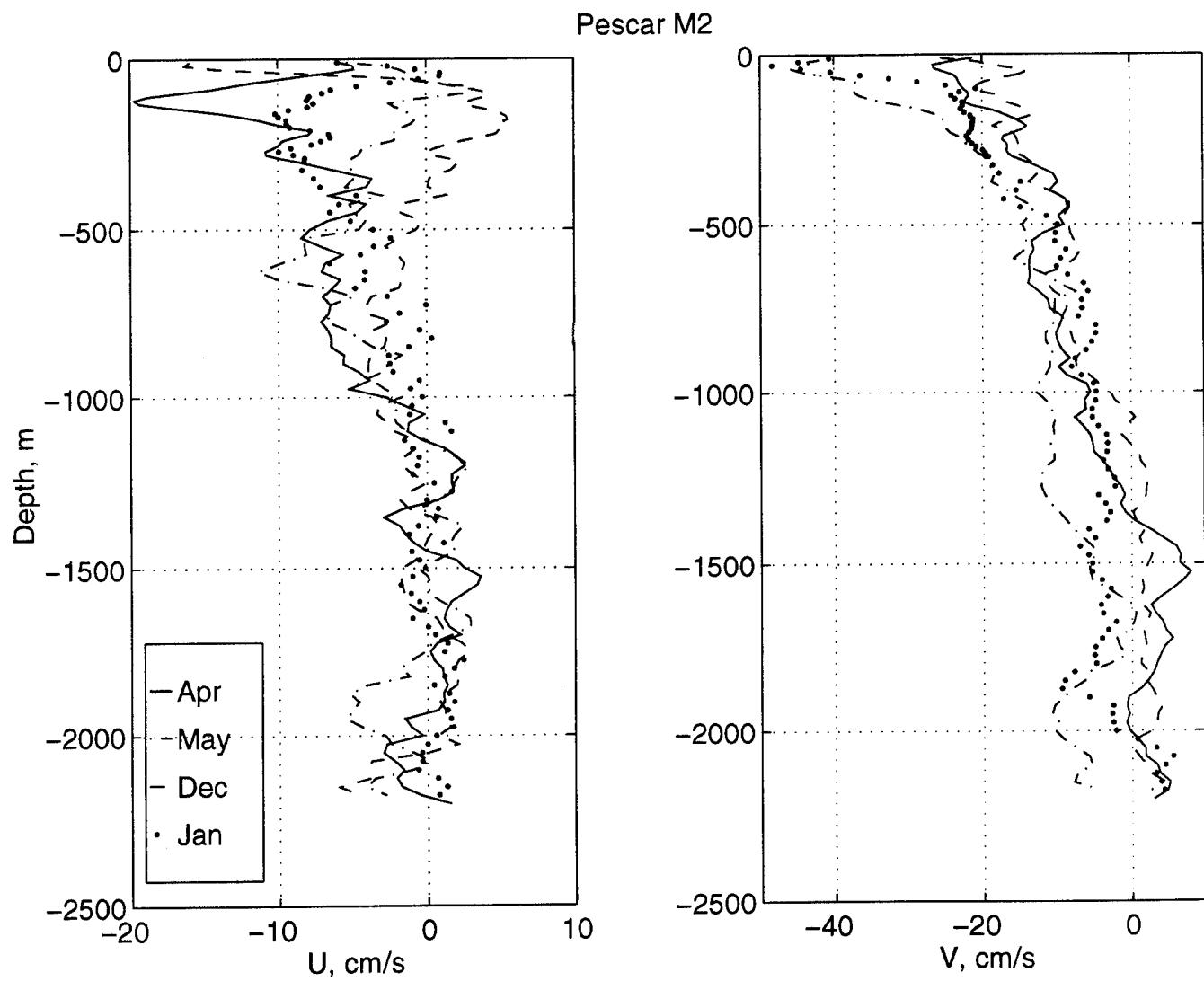


Figure M2-3. Mean velocity profiles at station M2 for each cruise leg. Left panel: East-west velocity component. Right panel: North-south velocity component.

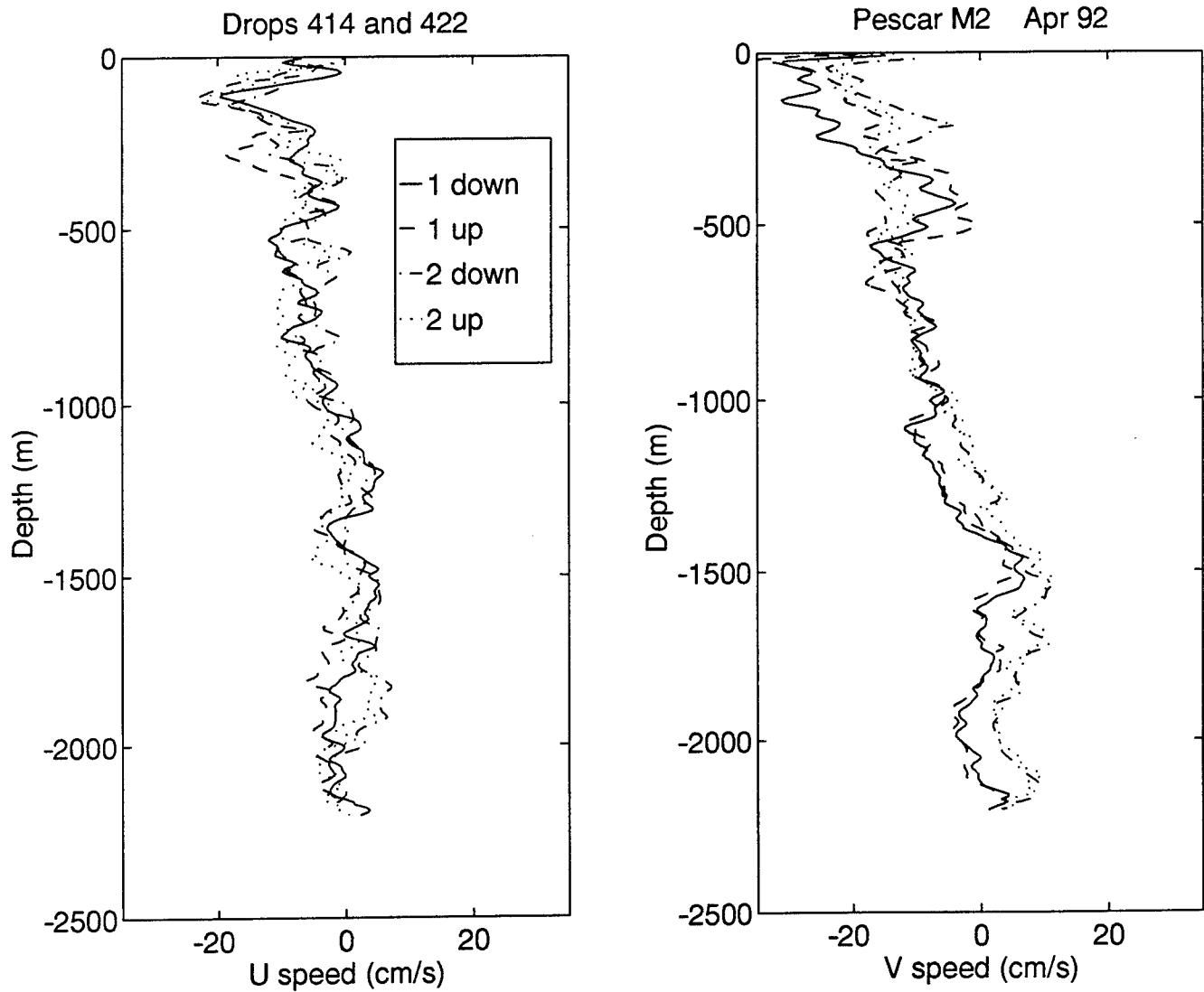


Figure M2-4. Velocity profiles at station M2 for Pegasus drops 414 and 422. Left panel: East-west velocity component. Right panel: North-south velocity component.

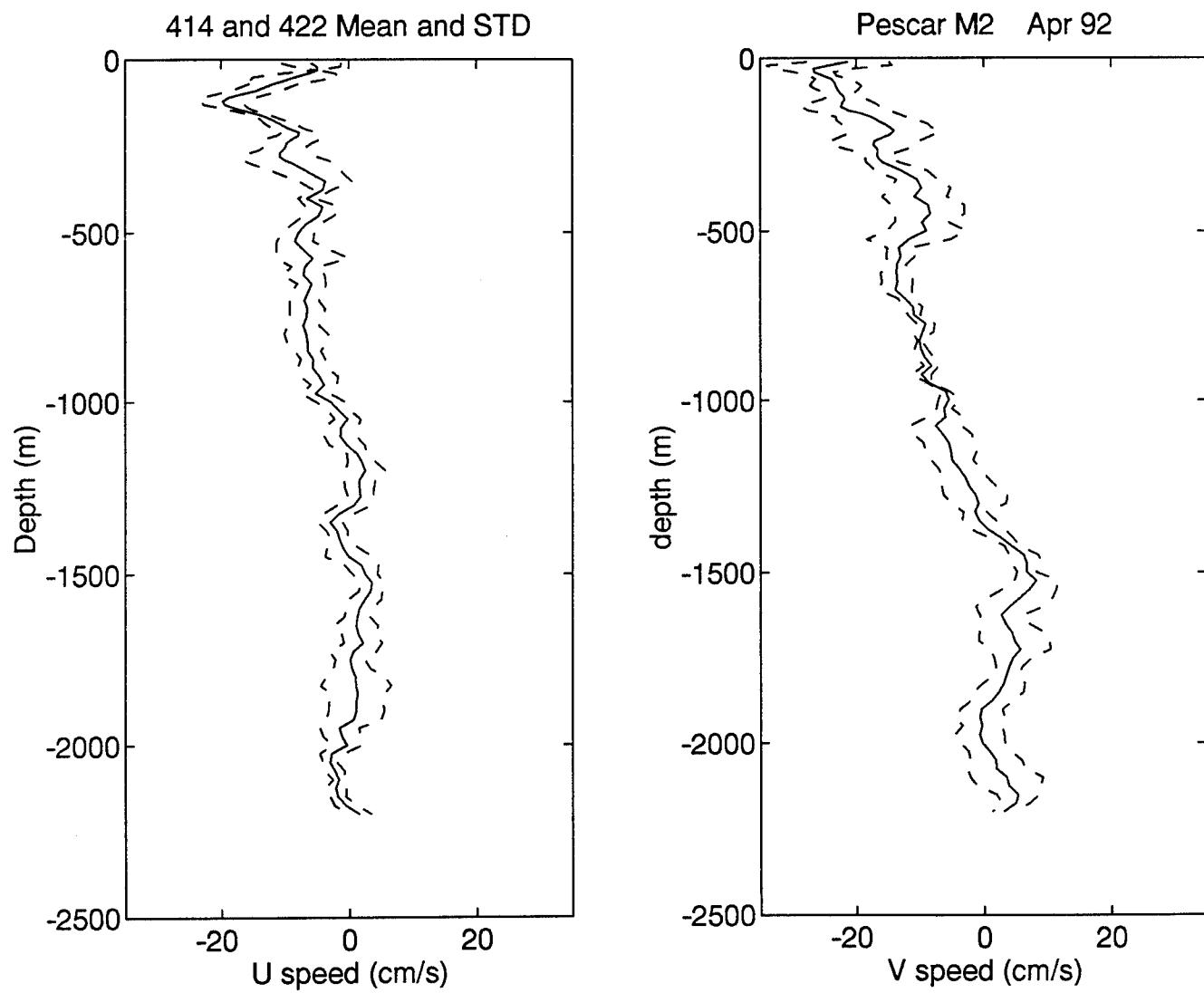


Figure M2-4 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

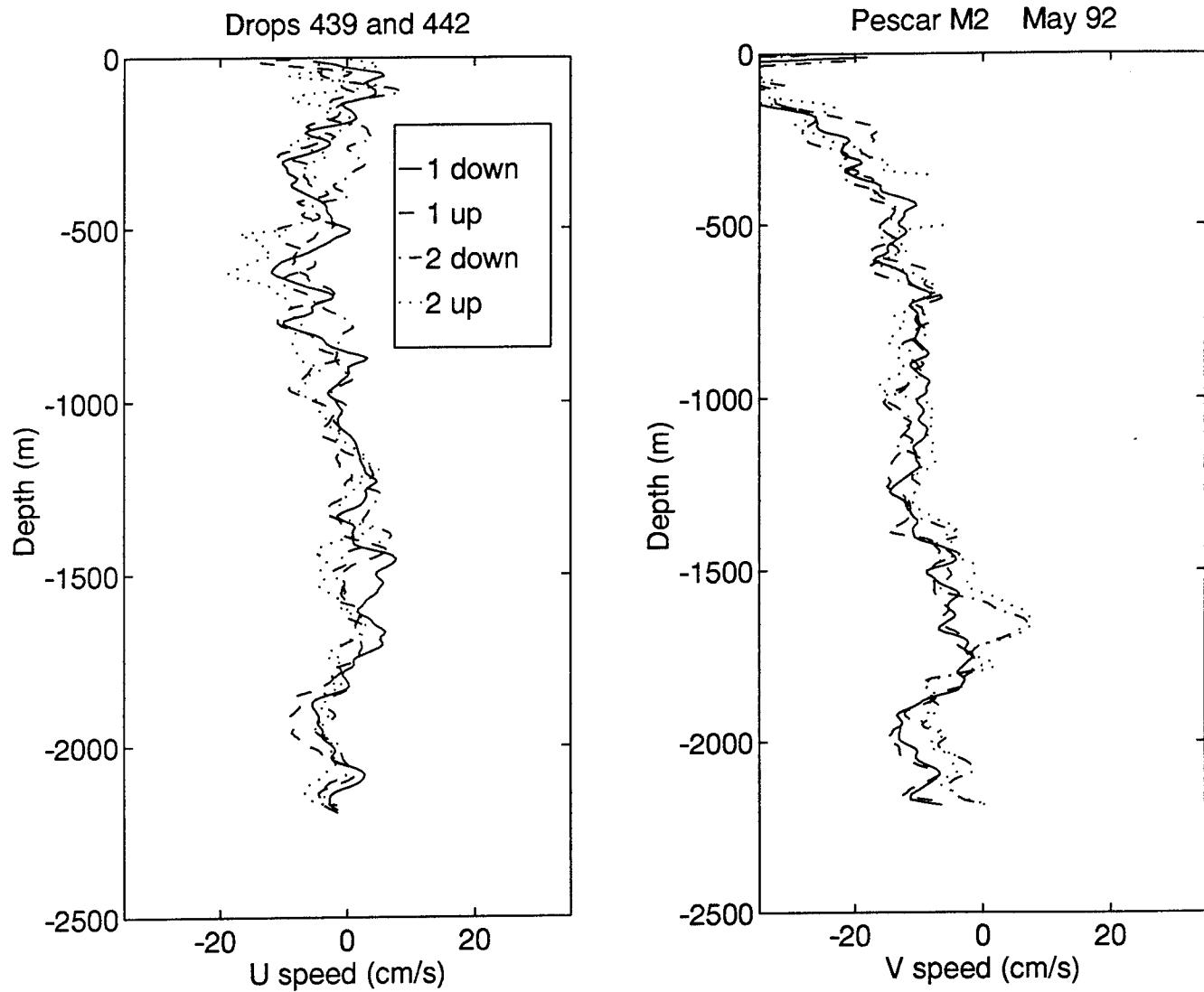


Figure M2-5. Velocity profiles at station M2 for Pegasus drops 439 and 442. Left panel: East-west velocity component. Right panel: North-south velocity component.

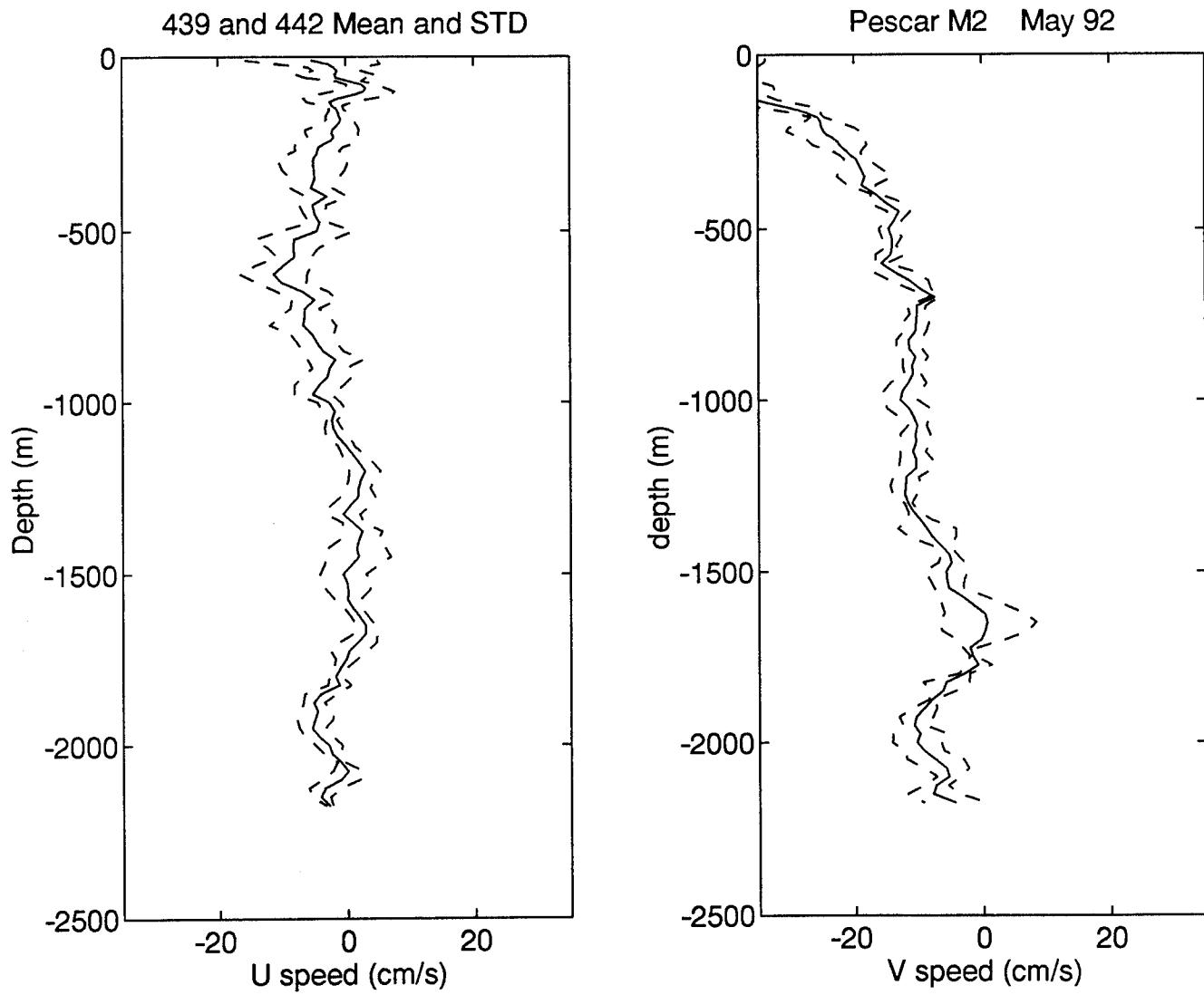


Figure M2-5 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

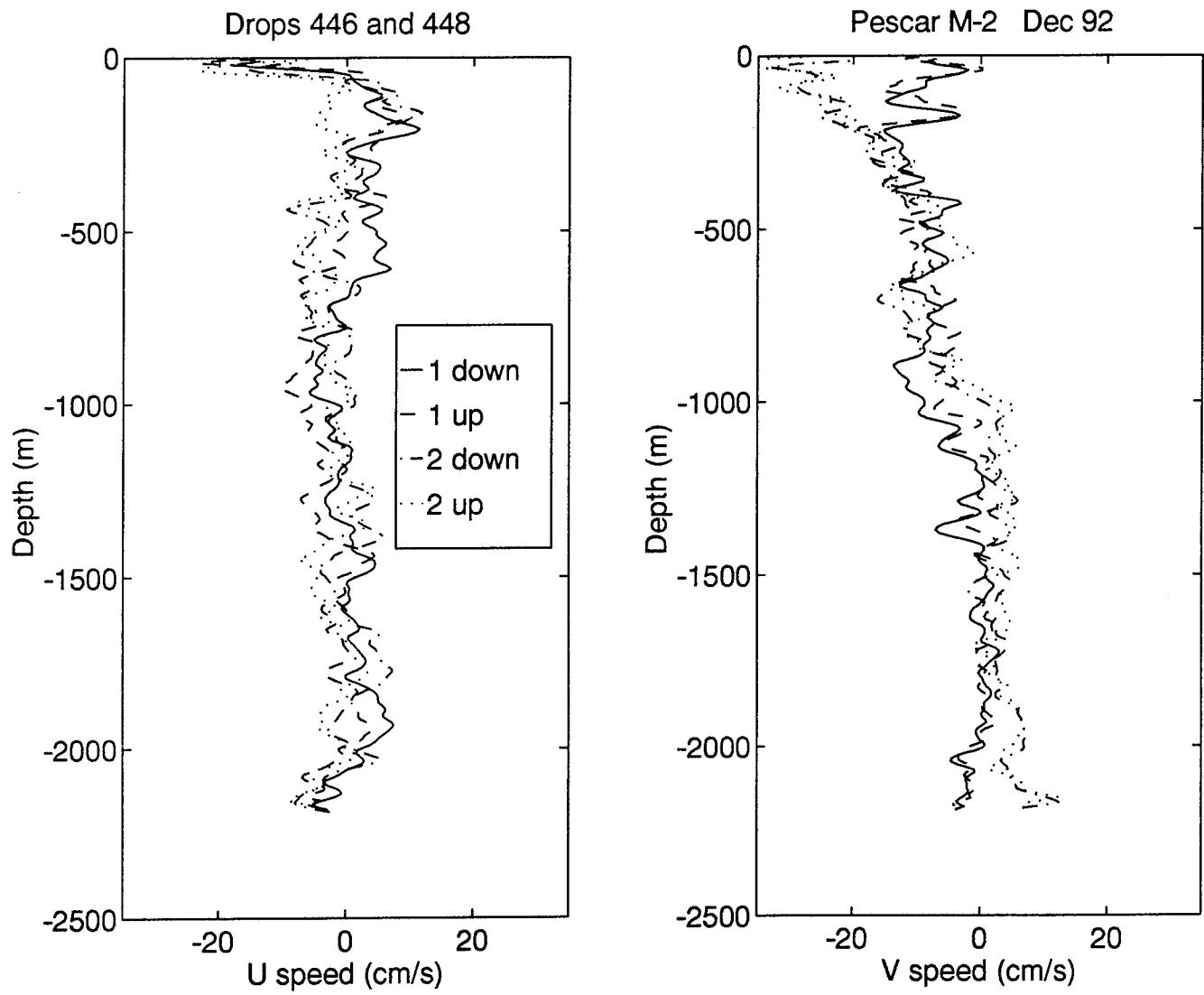


Figure M2-6. Velocity profiles at station M2 for Pegasus drops 446 and 448. Left panel: East-west velocity component. Right panel: North-south velocity component.

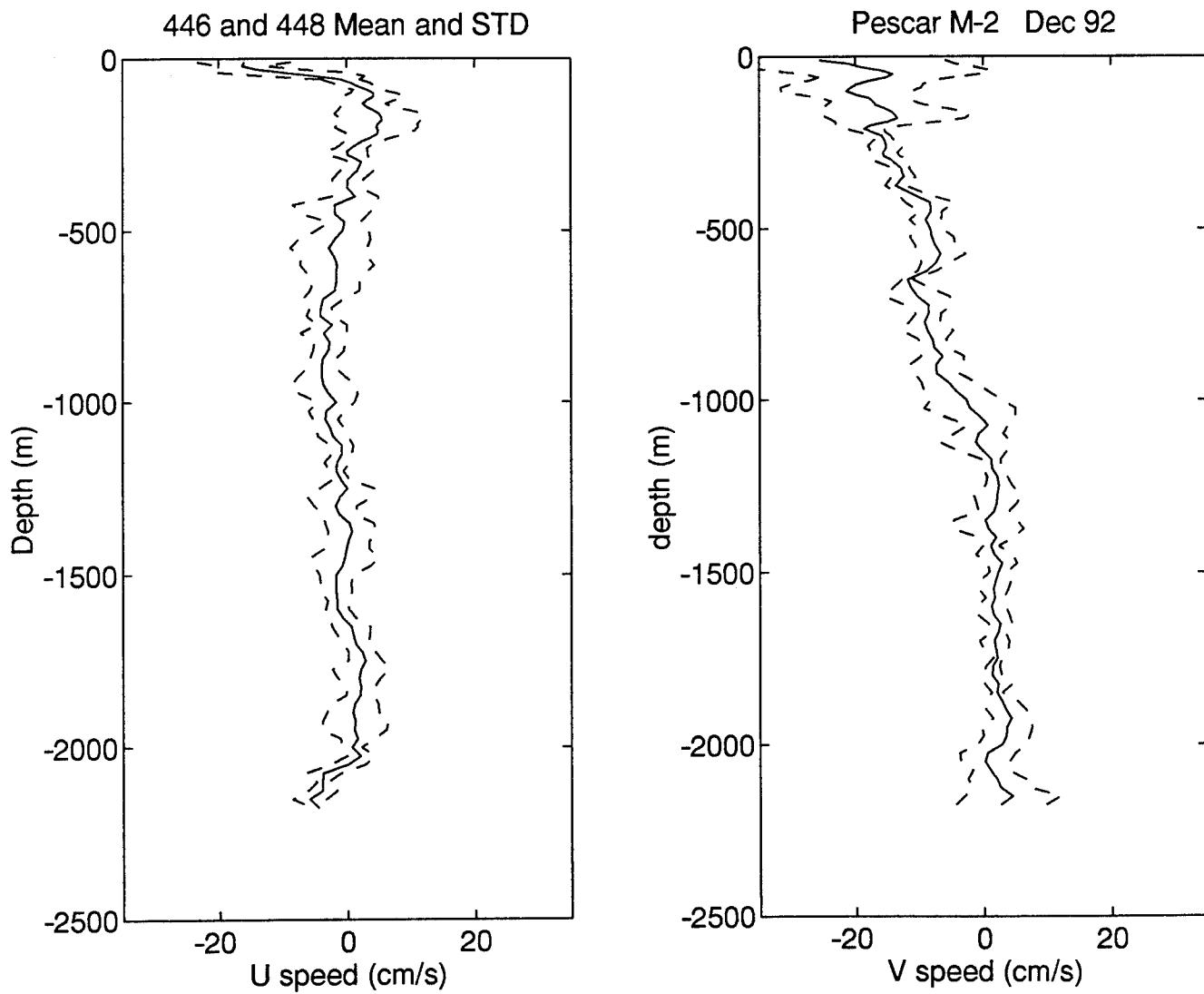


Figure M2-6 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

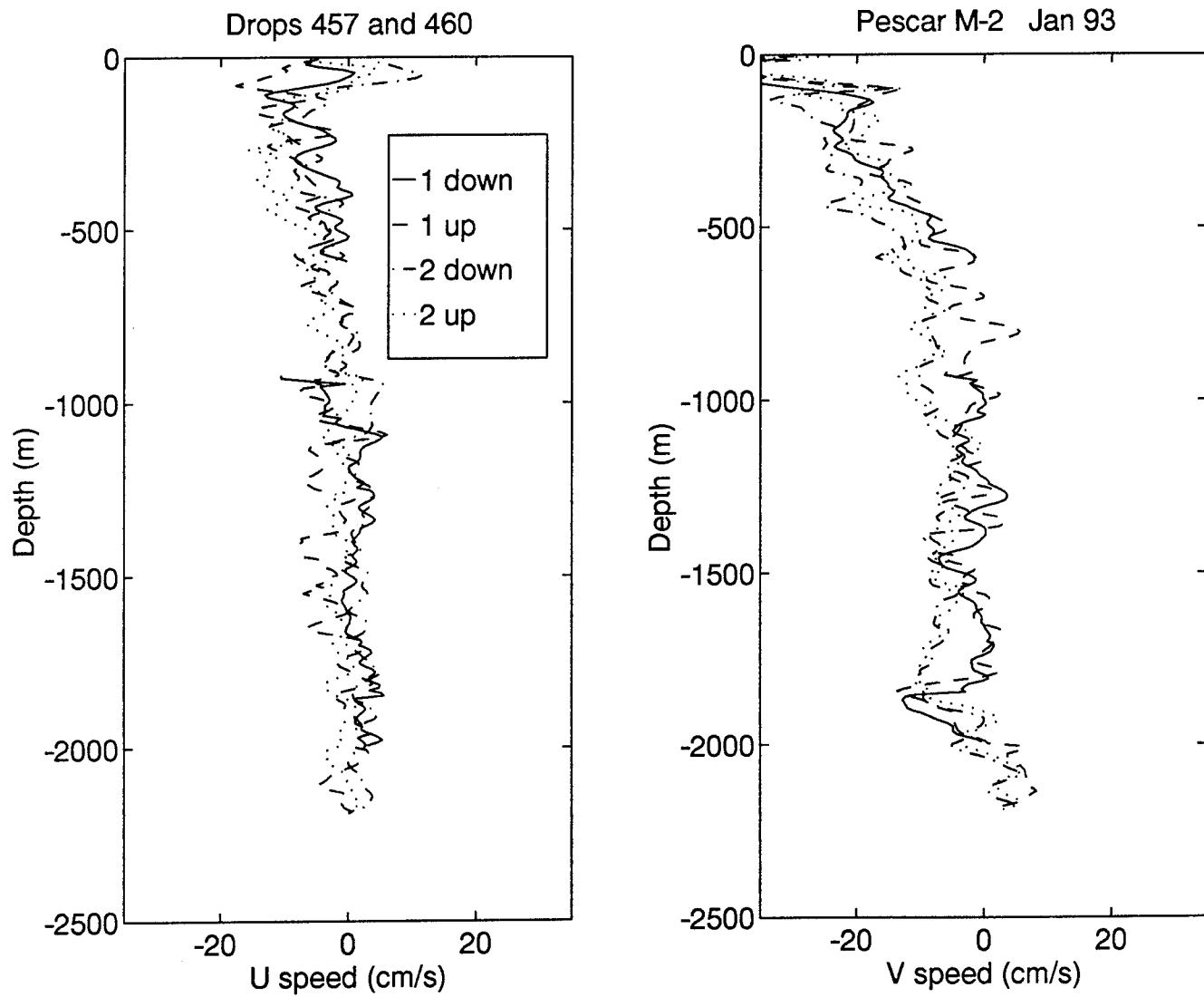


Figure M2-7. Velocity profiles at station M2 for Pegasus drops 457 and 460. Left panel: East-west velocity component. Right panel: North-south velocity component.

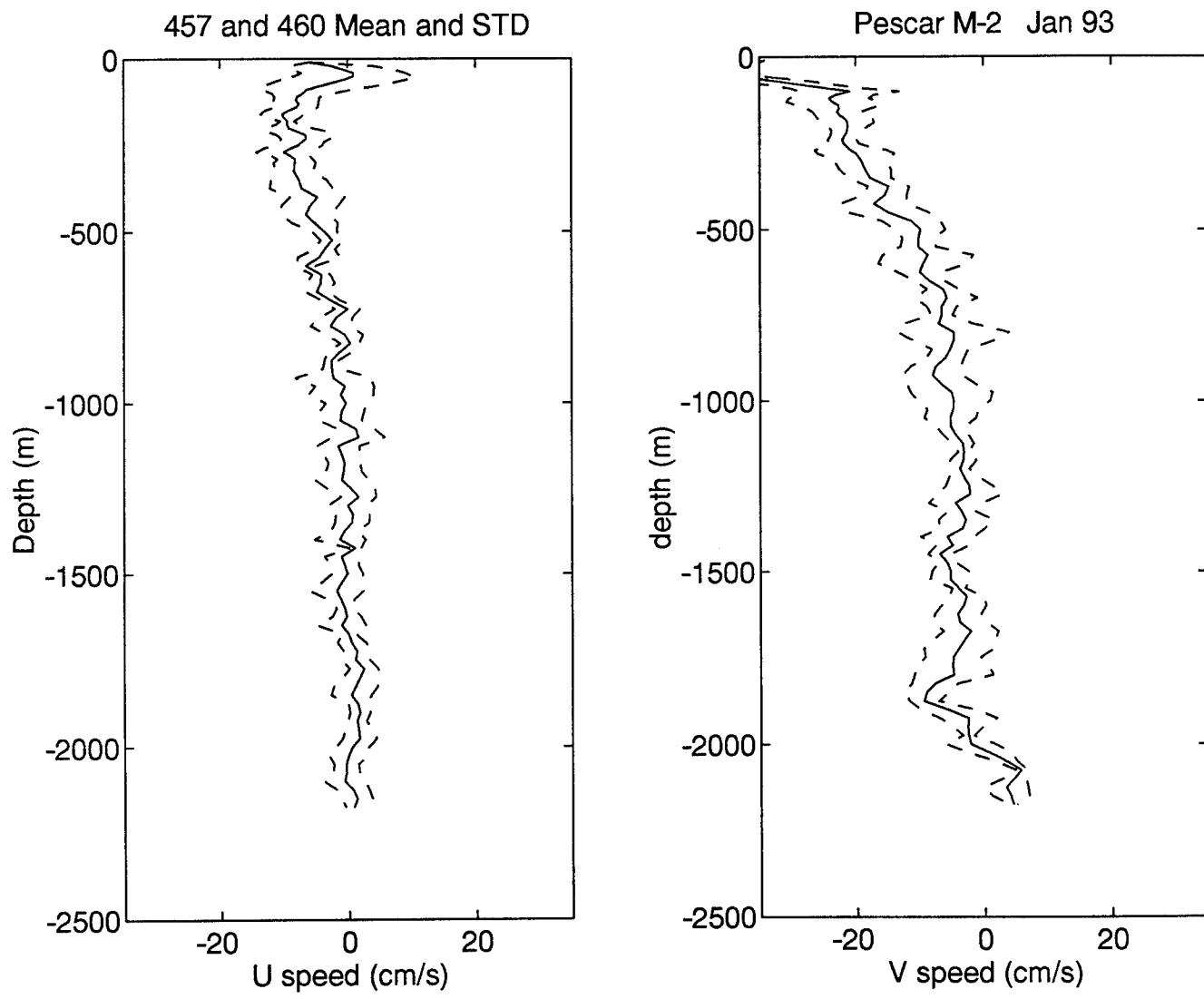


Figure M2-7 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

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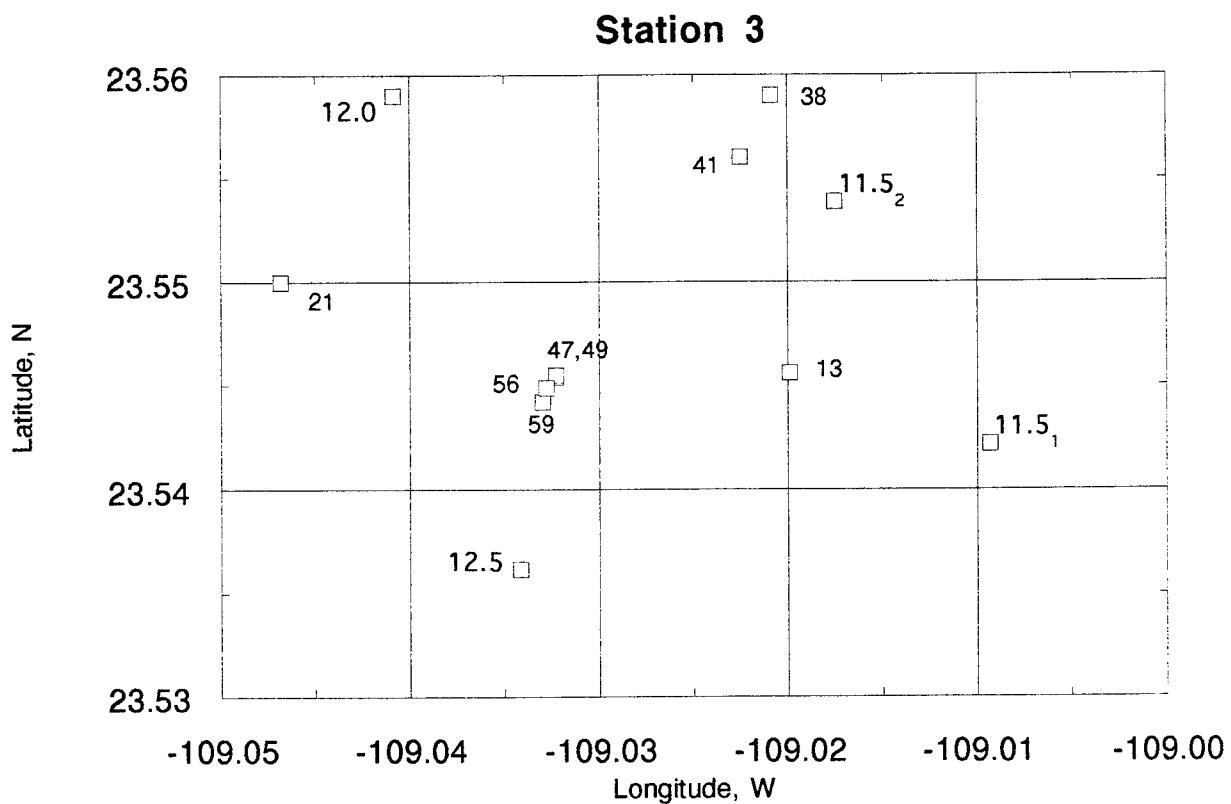


Figure M3-1. Pegasus launch and transponder positions at station M3. Transponders are identified by their reply frequency (11.5, 12.0 and 12.5 kHz) and launch positions are identified by the last two digits of the drop number given in Table 1. The subscripts for the 11.5 kHz transponder are due to the fact that the first transponder (subscript 1) failed and was replaced by a second transponder for January 1993 Pegasus observations.

### Station 3

origin is 23.554N, 109.018W

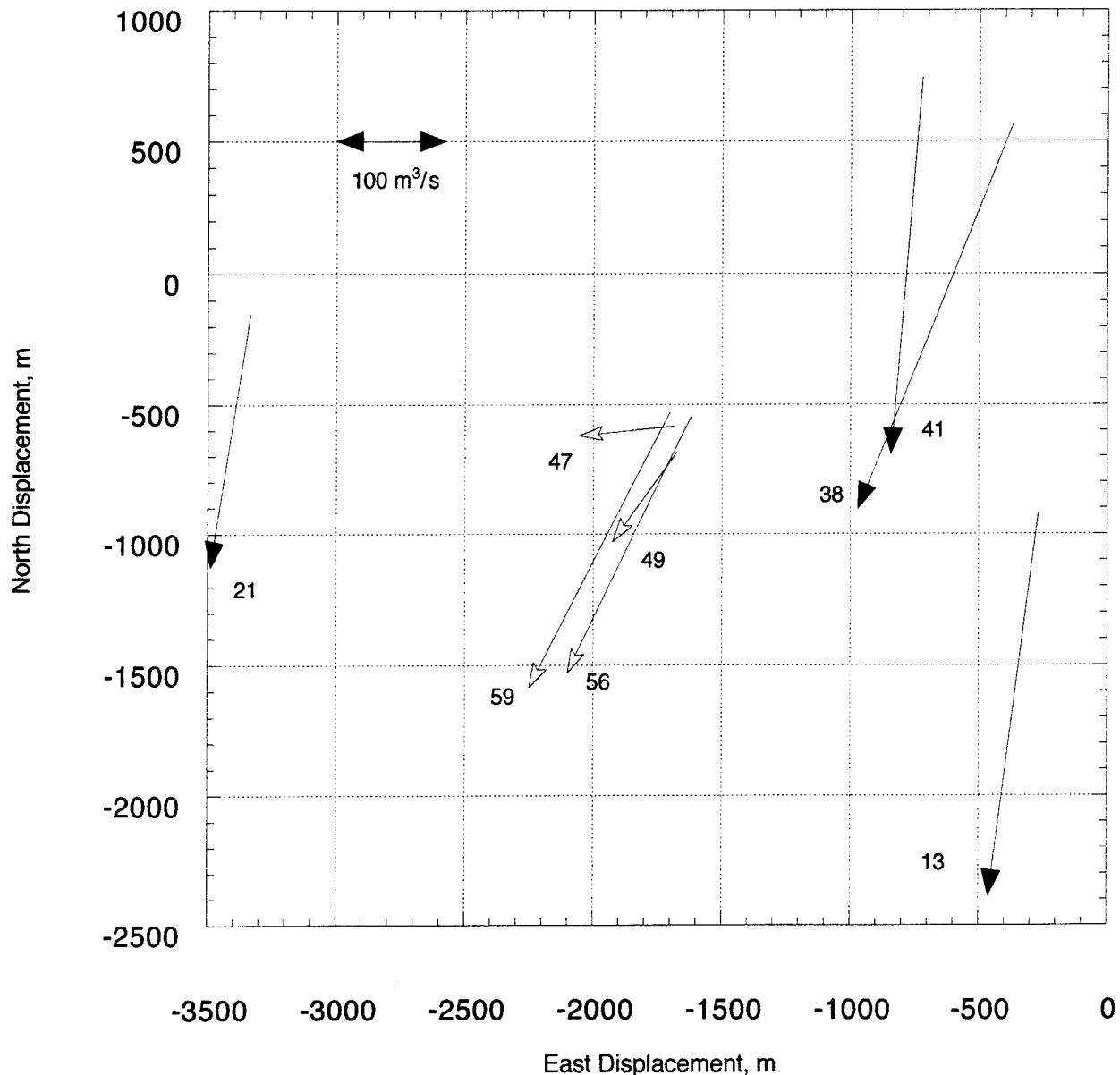


Figure M3-2. Transport measurements at station M3. Vectors connect the launch and surfacing position of Pegasus. The two digit numbers next to the vectors are the last two digits of the drop number given in Table 1. Solid arrow heads indicate observations made during the cruise which began in April 1992 and open arrow heads indicate observations made during the cruise which began in December 1992. Transport values assume a one square meter column of water with a thickness equal to the water depth.

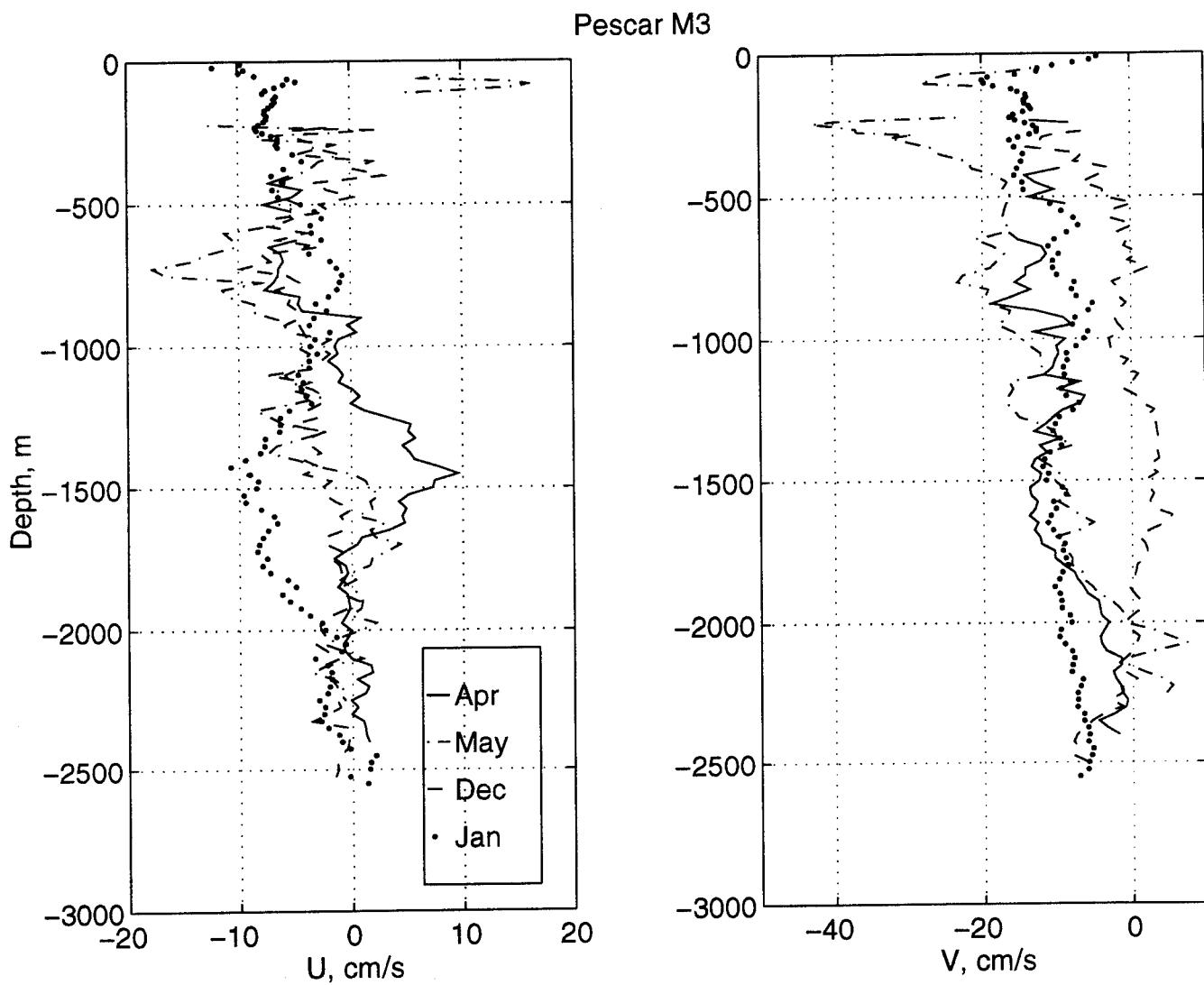


Figure M3-3. Mean velocity profiles at station M3 for each cruise leg. Left panel: East-west velocity component. Right panel: North-south velocity component.

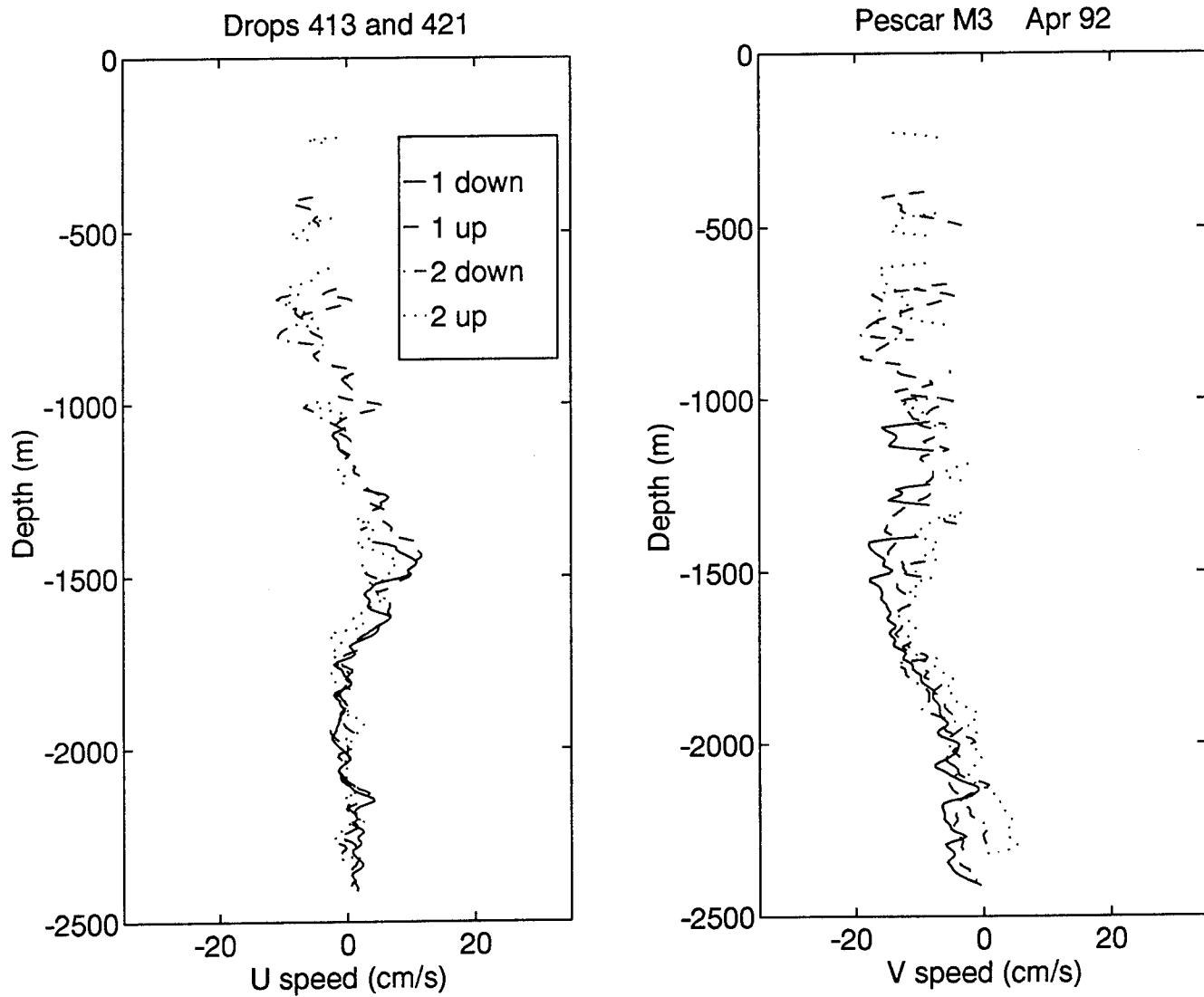


Figure M3-4. Velocity profiles at station M3 for Pegasus drops 413 and 421. Left panel: East-west velocity component. Right panel: North-south velocity component.

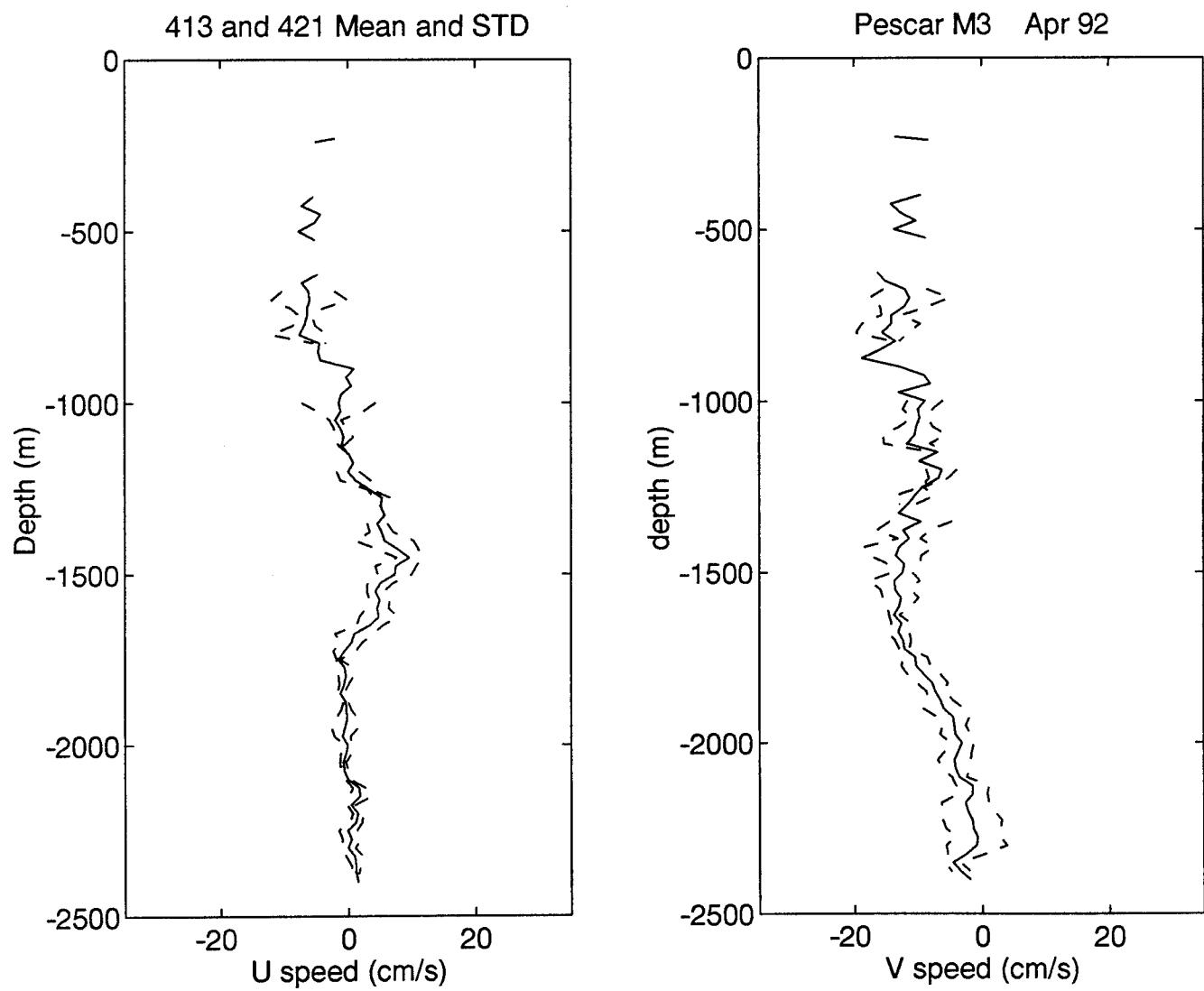


Figure M3-4 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

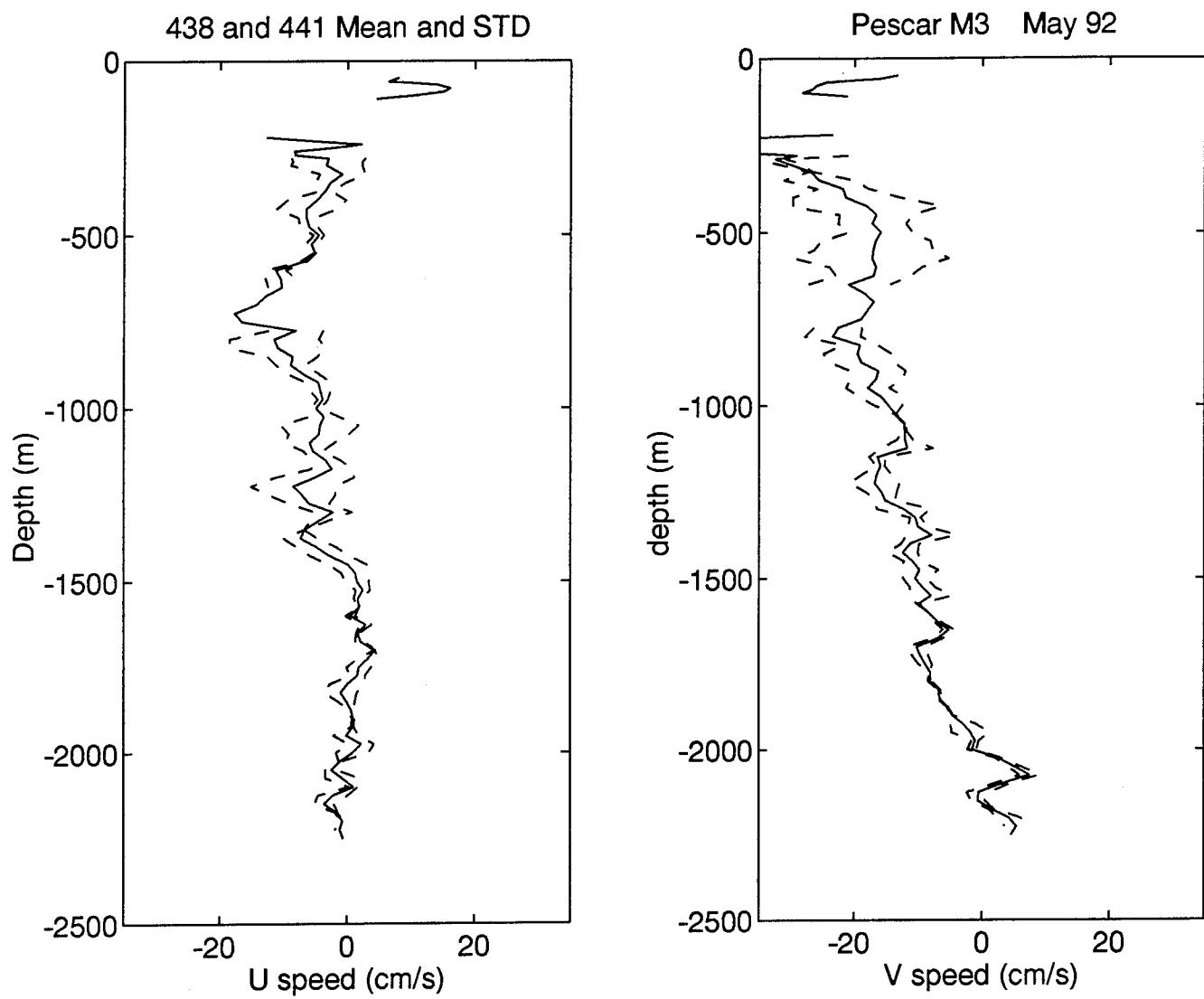


Figure M3-5. Velocity profiles at station M3 for Pegasus drops 438 and 441. Left panel: East-west velocity component. Right panel: North-south velocity component.

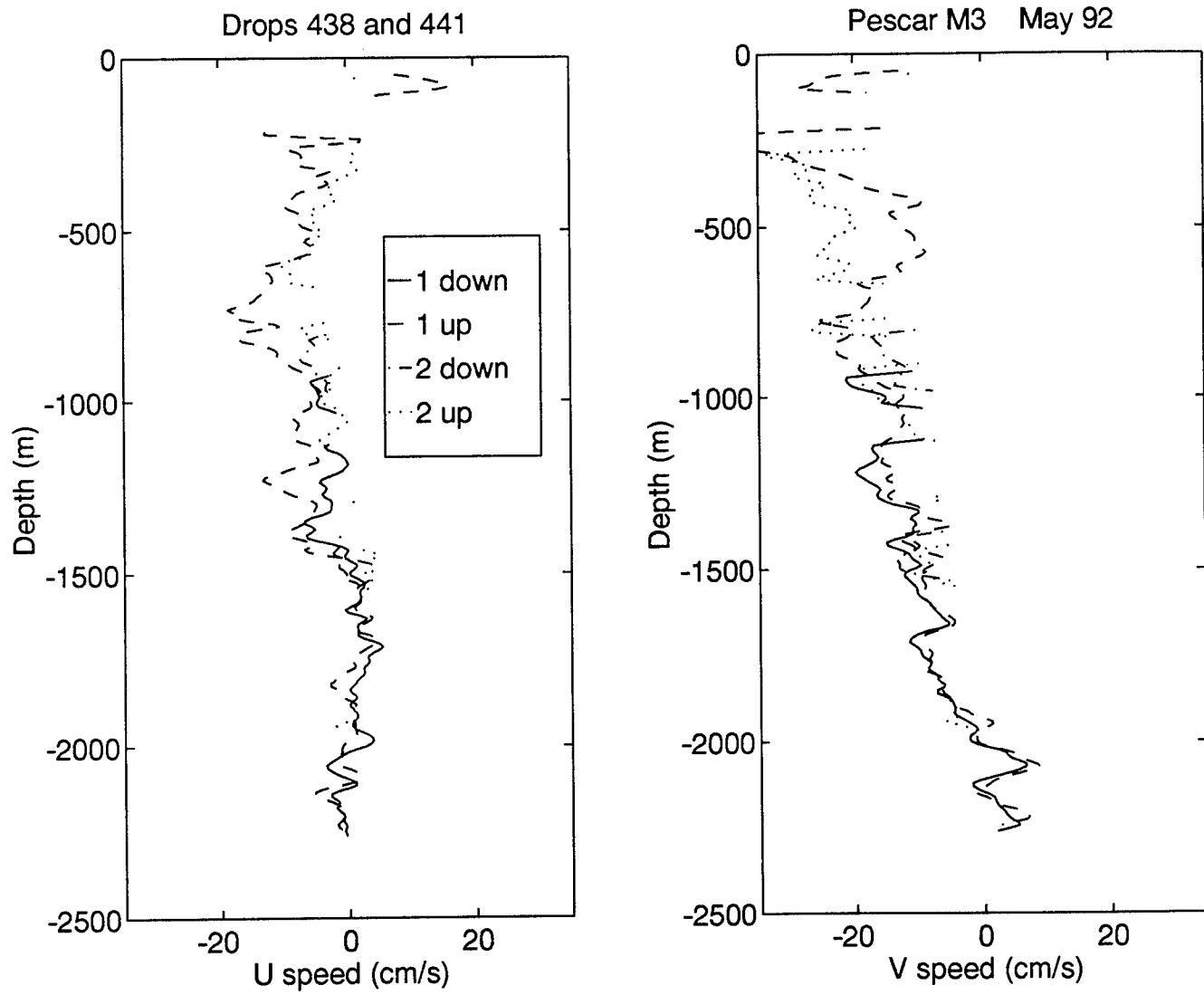


Figure M3-5 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

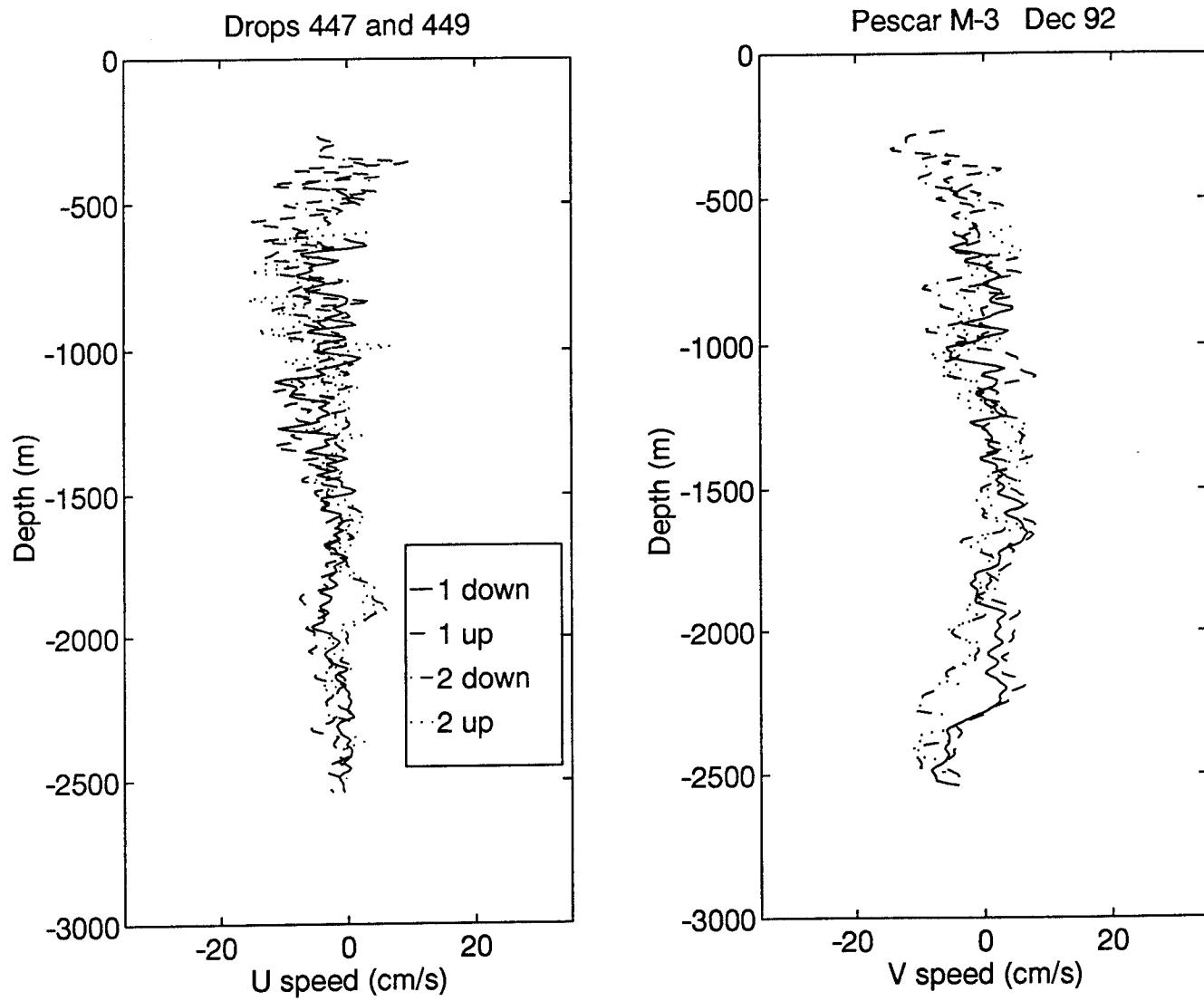


Figure M3-6. Velocity profiles at station M3 for Pegasus drops 447 and 449. Left panel: East-west velocity component. Right panel: North-south velocity component.

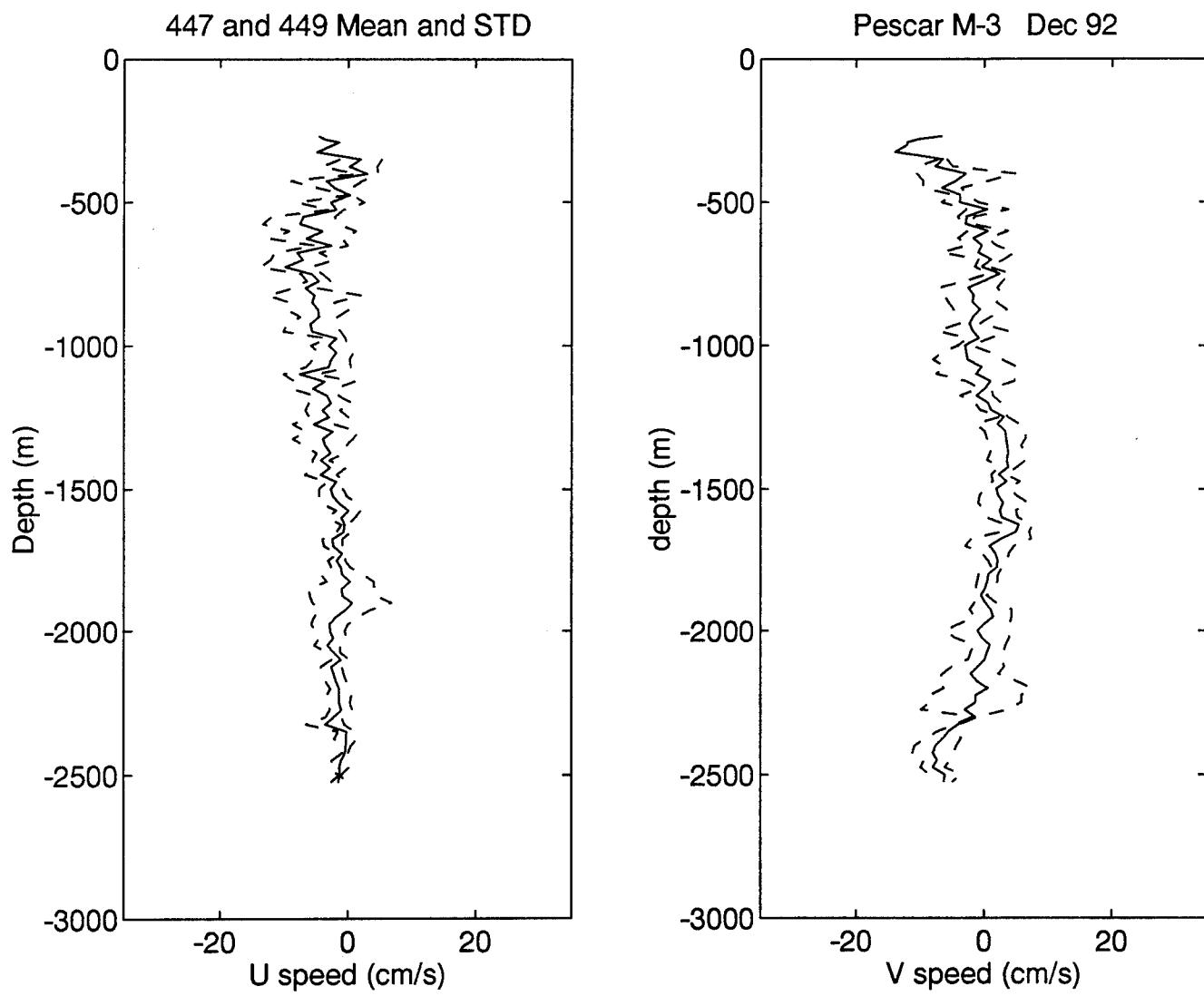


Figure M3-6 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

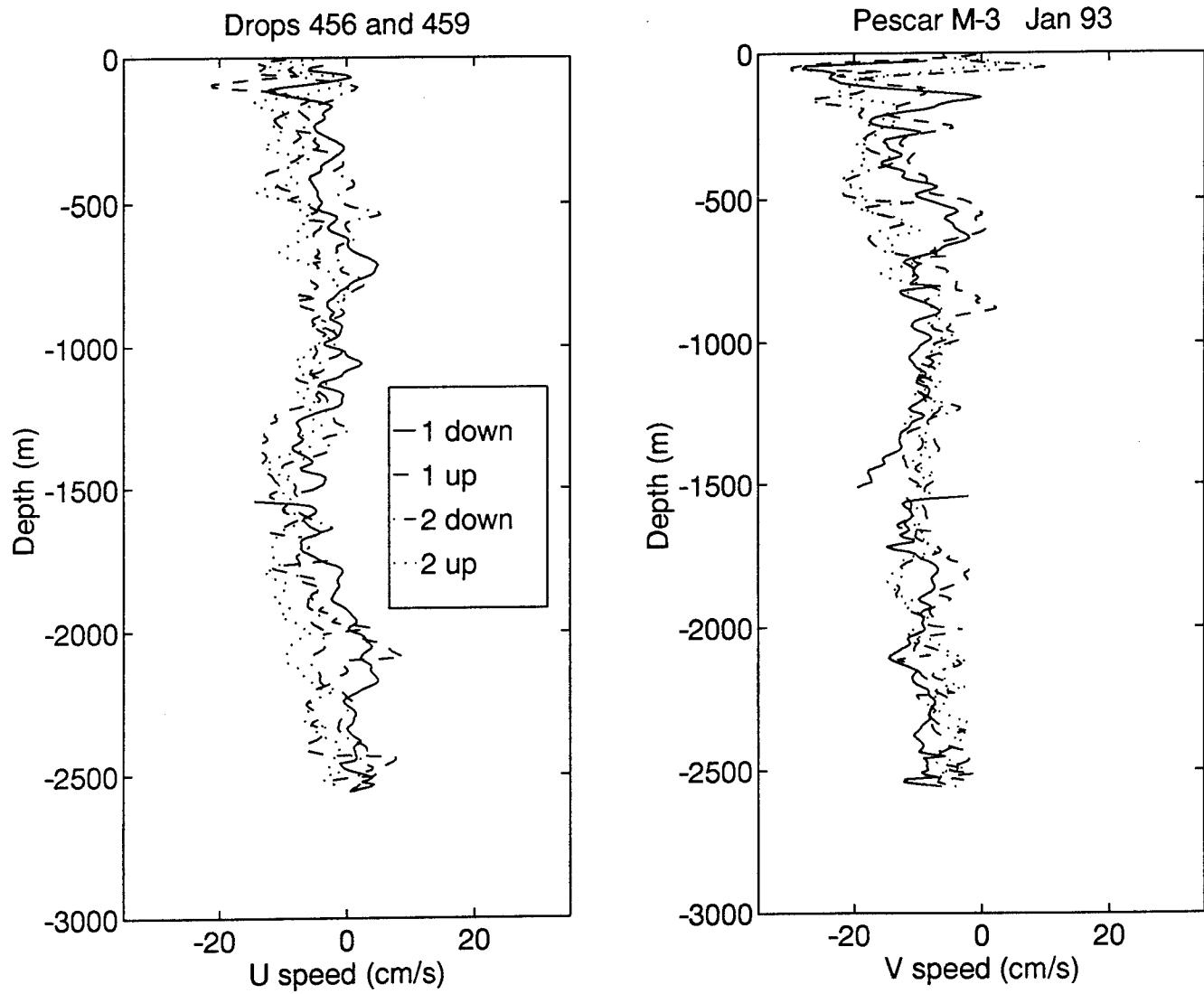


Figure M3-7. Velocity profiles at station M3 for Pegasus drops 456 and 459. Left panel: East-west velocity component. Right panel: North-south velocity component.

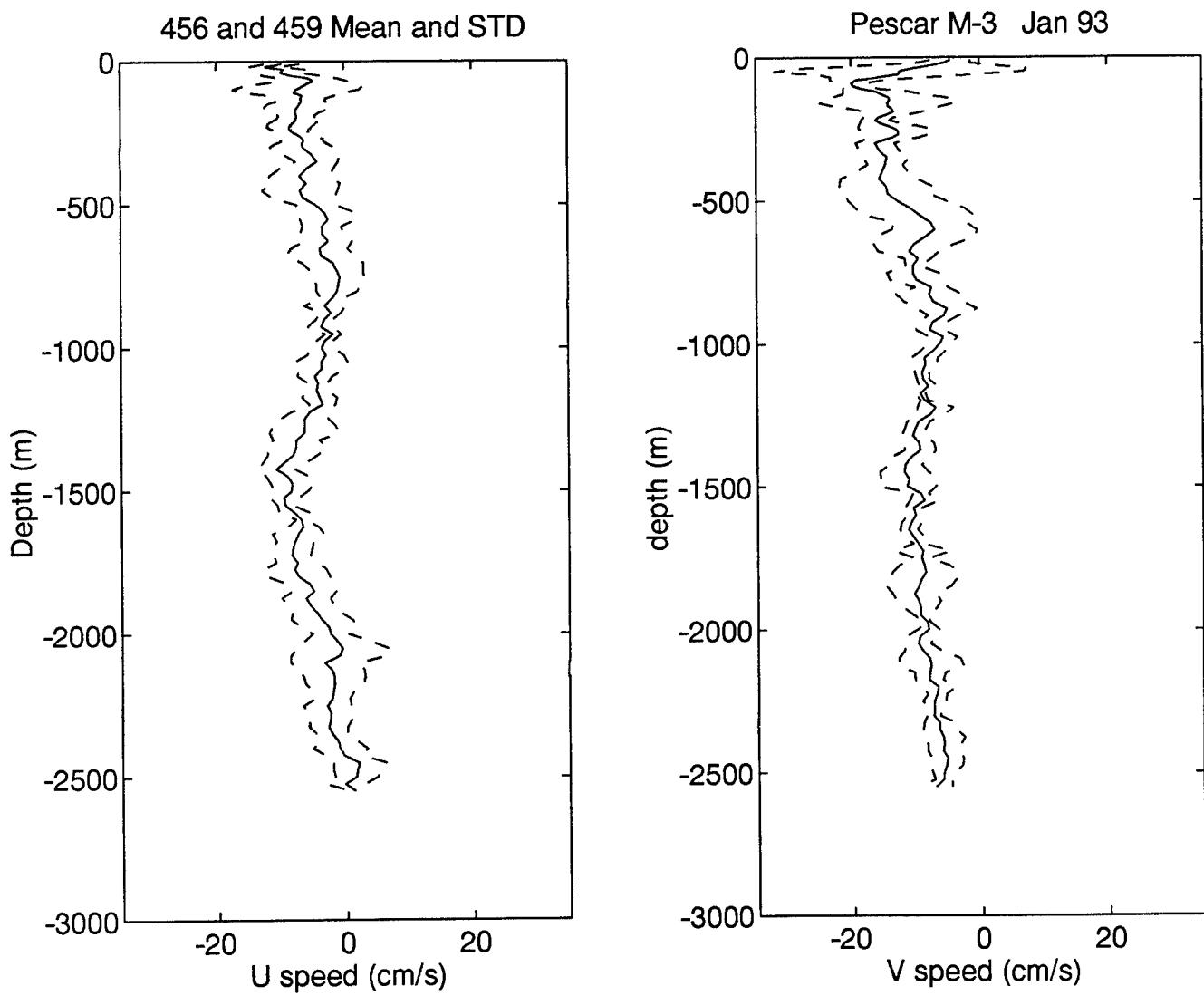
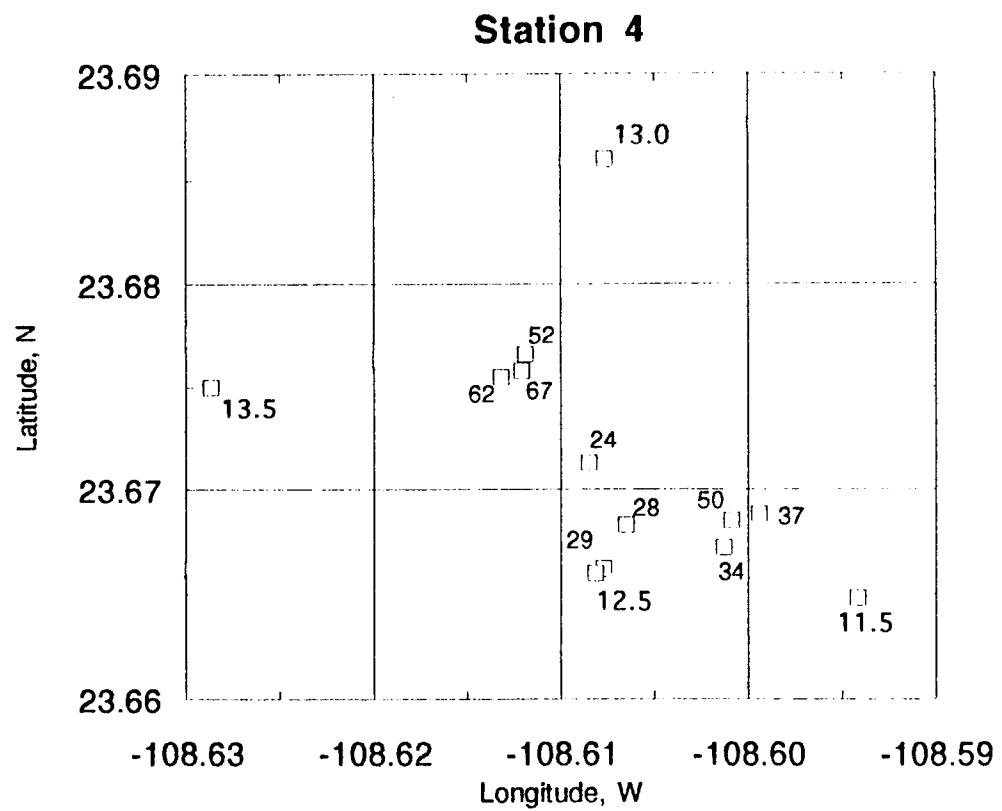


Figure M3-7 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

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**Figure M4-1.** Pegasus launch and transponder positions at station M4. Transponders are identified by their reply frequency (11.5, 13.0, 12.5 and 13.5 kHz) and launch positions are identified by the last two digits of the drop number given in Table 1.

**Station 4**  
origin is 23.666N, 108.608W

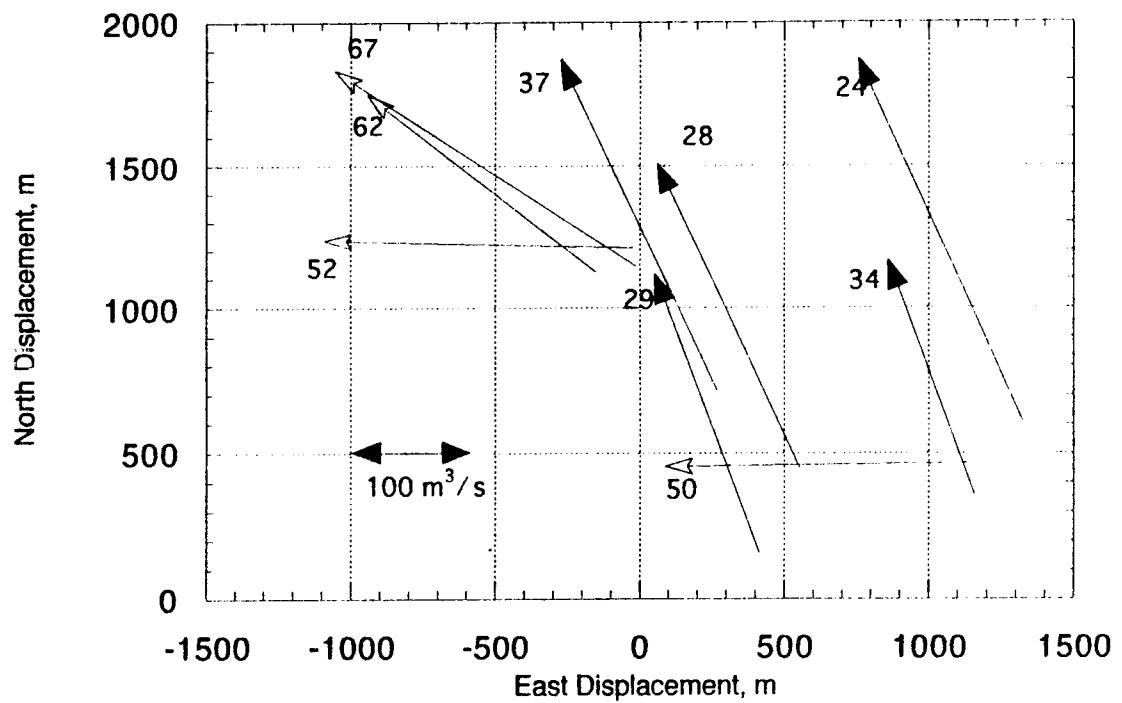


Figure M4-2. Transport measurements at station M4. Vectors connect the launch and surfacing position of Pegasus. The two digit numbers next to the vectors are the last two digits of the drop number given in Table 1. Solid arrow heads indicate observations made during the cruise which began in April 1992 and open arrow heads indicate observations made during the cruise which began in December 1992. Transport values assume a one square meter column of water with a thickness equal to the water depth.

Pescar M4

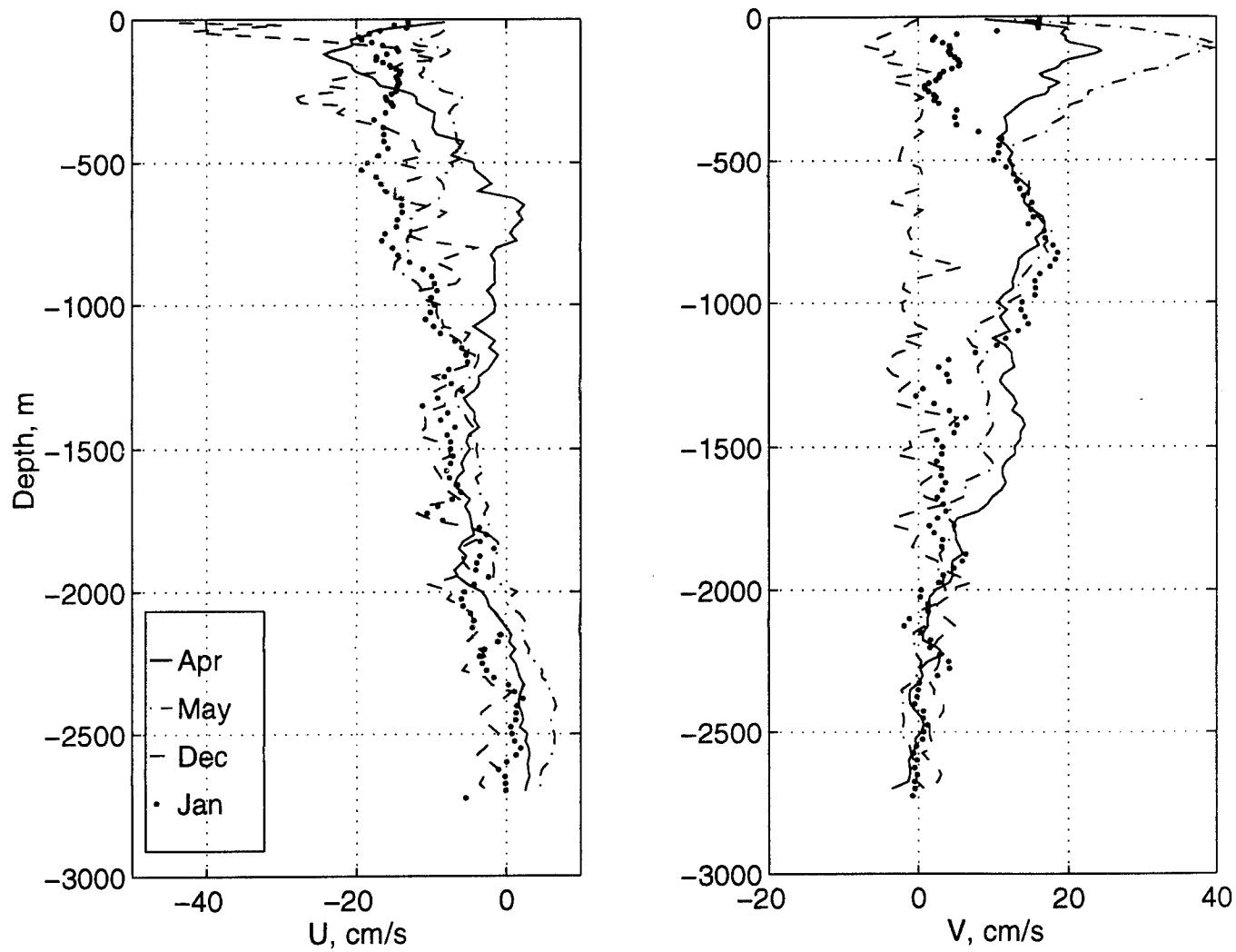
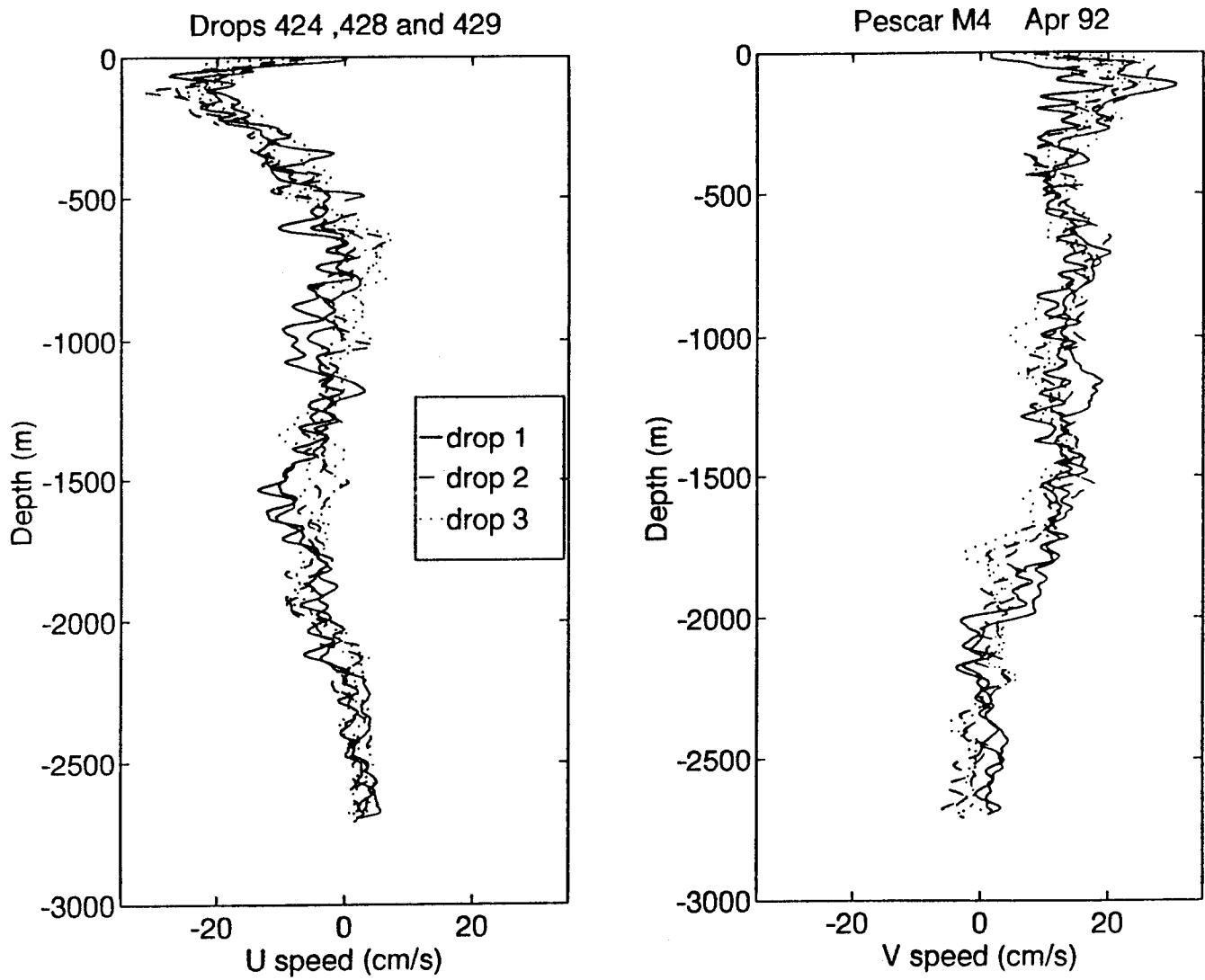


Figure M4-3. Mean velocity profiles at station M4 for each cruise leg. Left panel: East-west velocity component. Right panel: North-south velocity component.



**Figure M4-4.** Velocity profiles at station M4 for Pegasus drops 424, 428 and 429. Left panel: East-west velocity component. Right panel: North-south velocity component.

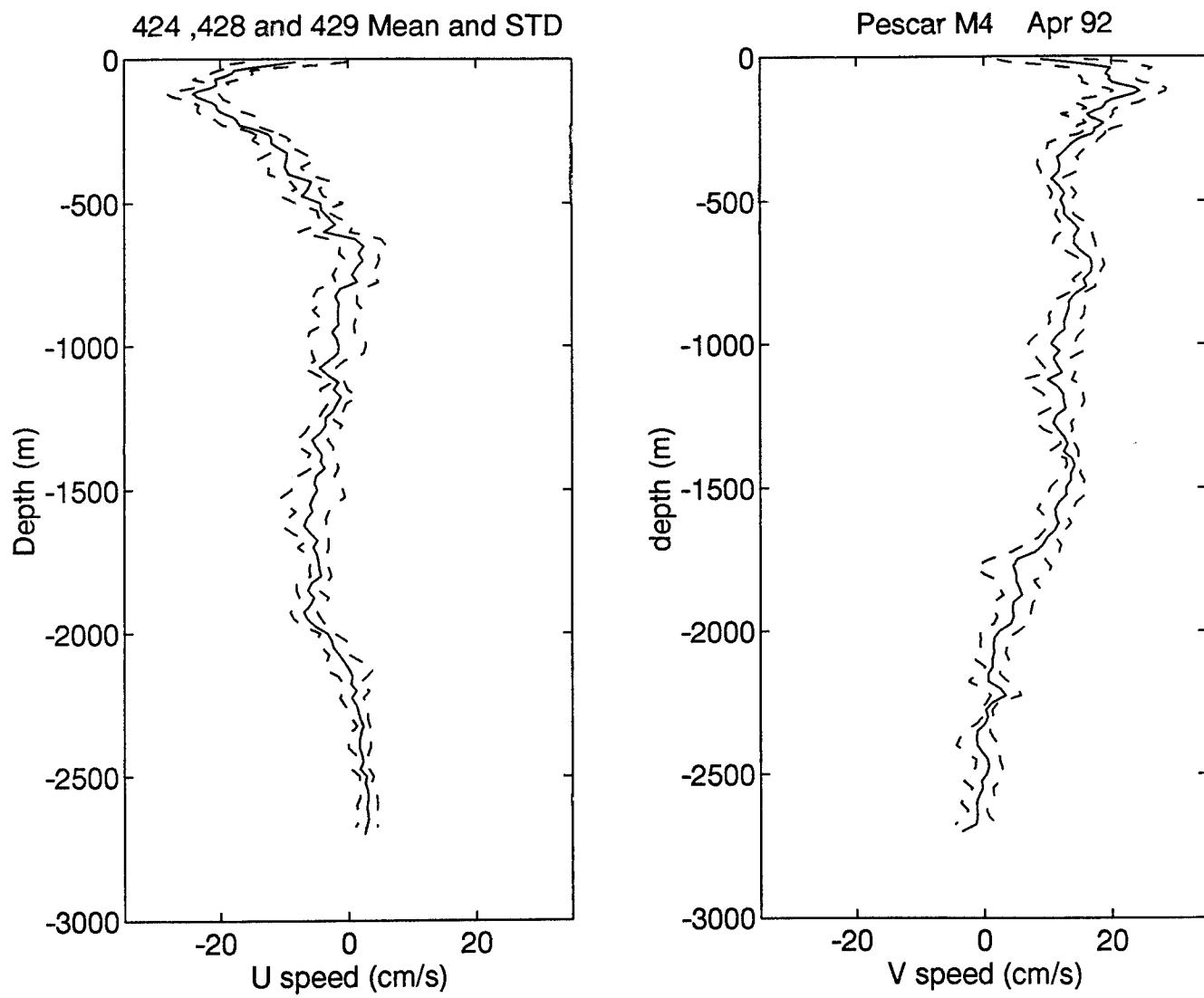


Figure M4-4 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

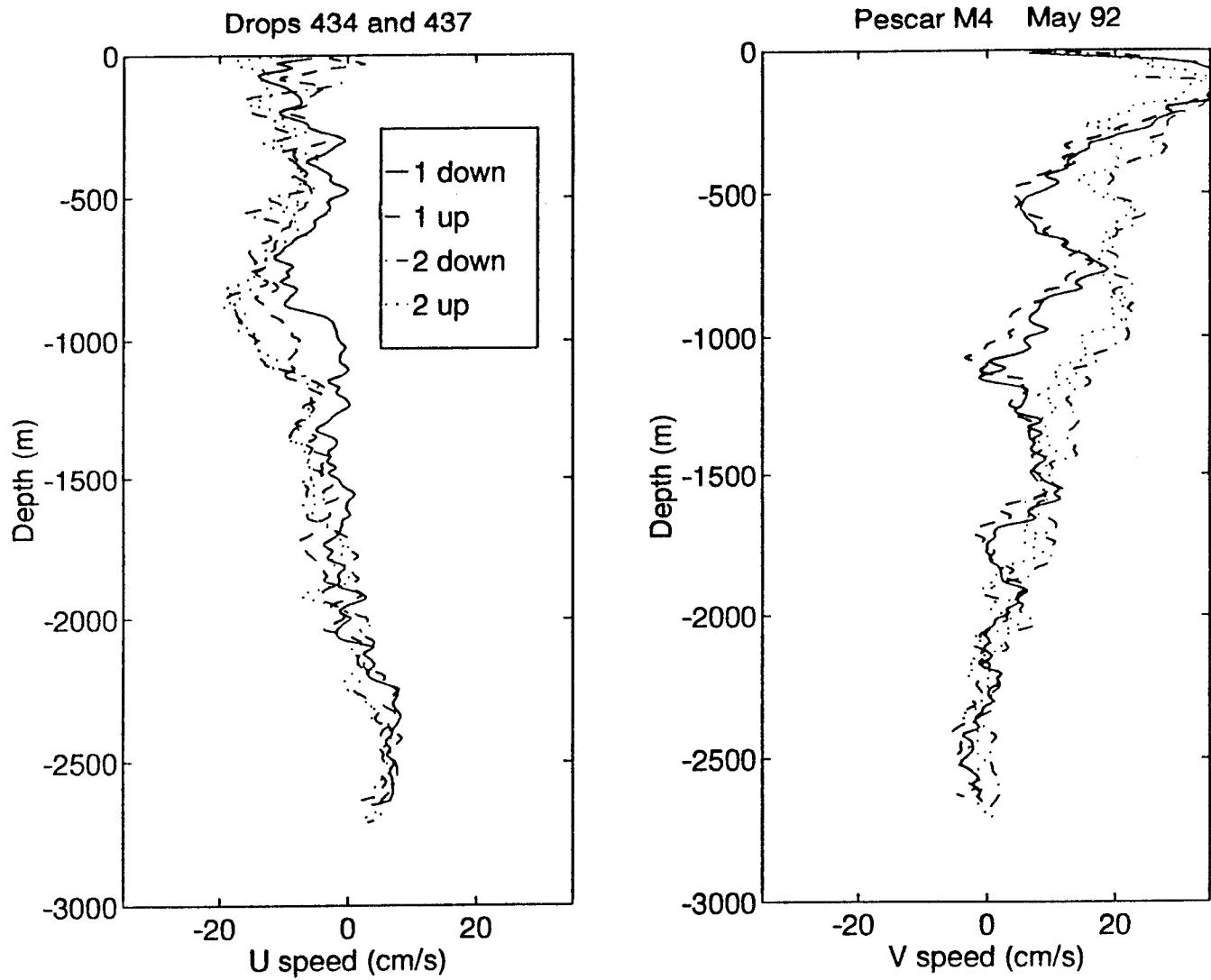


Figure M4-5. Velocity profiles at station M4 for Pegasus drops 434 and 437. Left panel: East-west velocity component. Right panel: North-south velocity component.

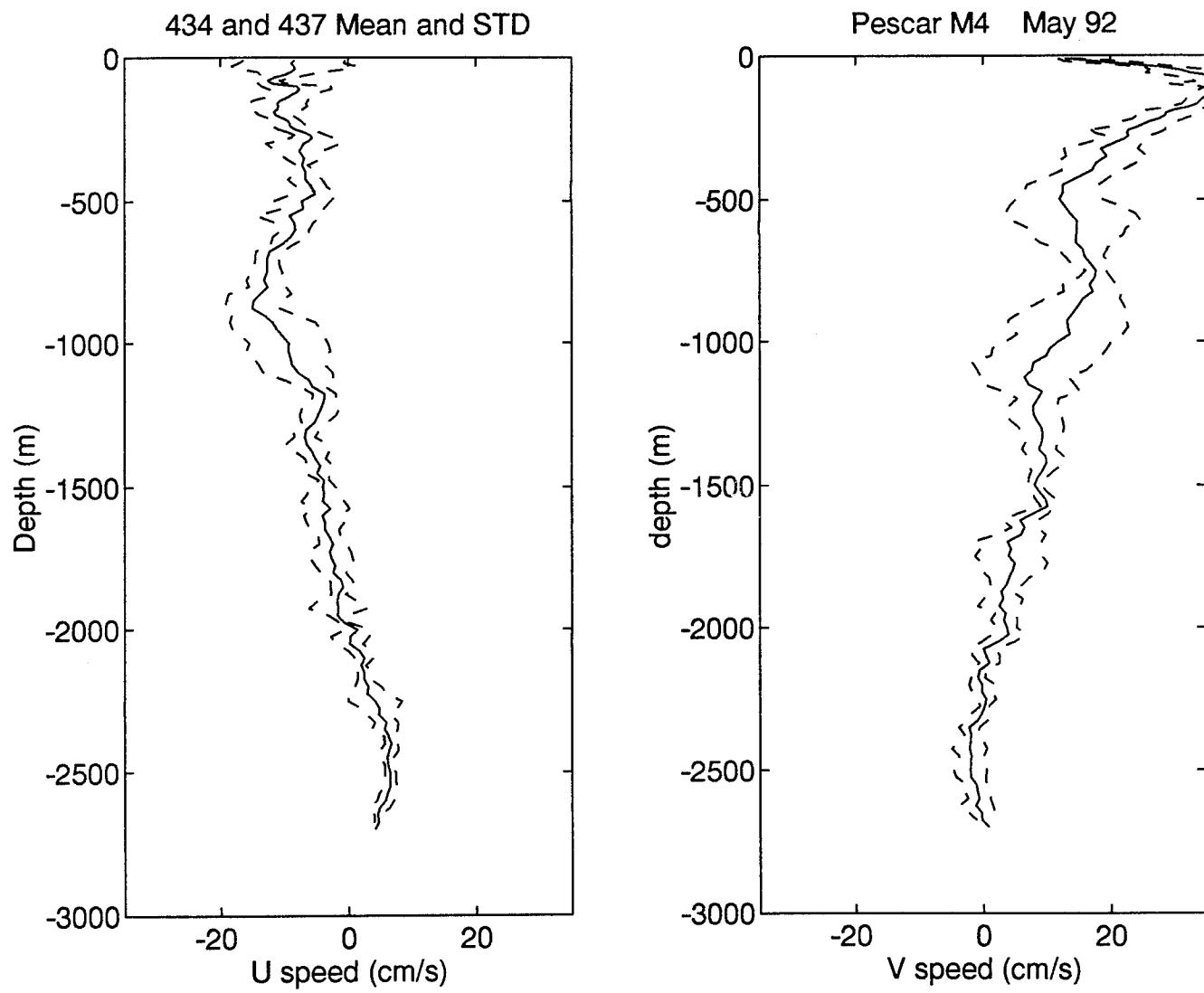


Figure M4-5 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

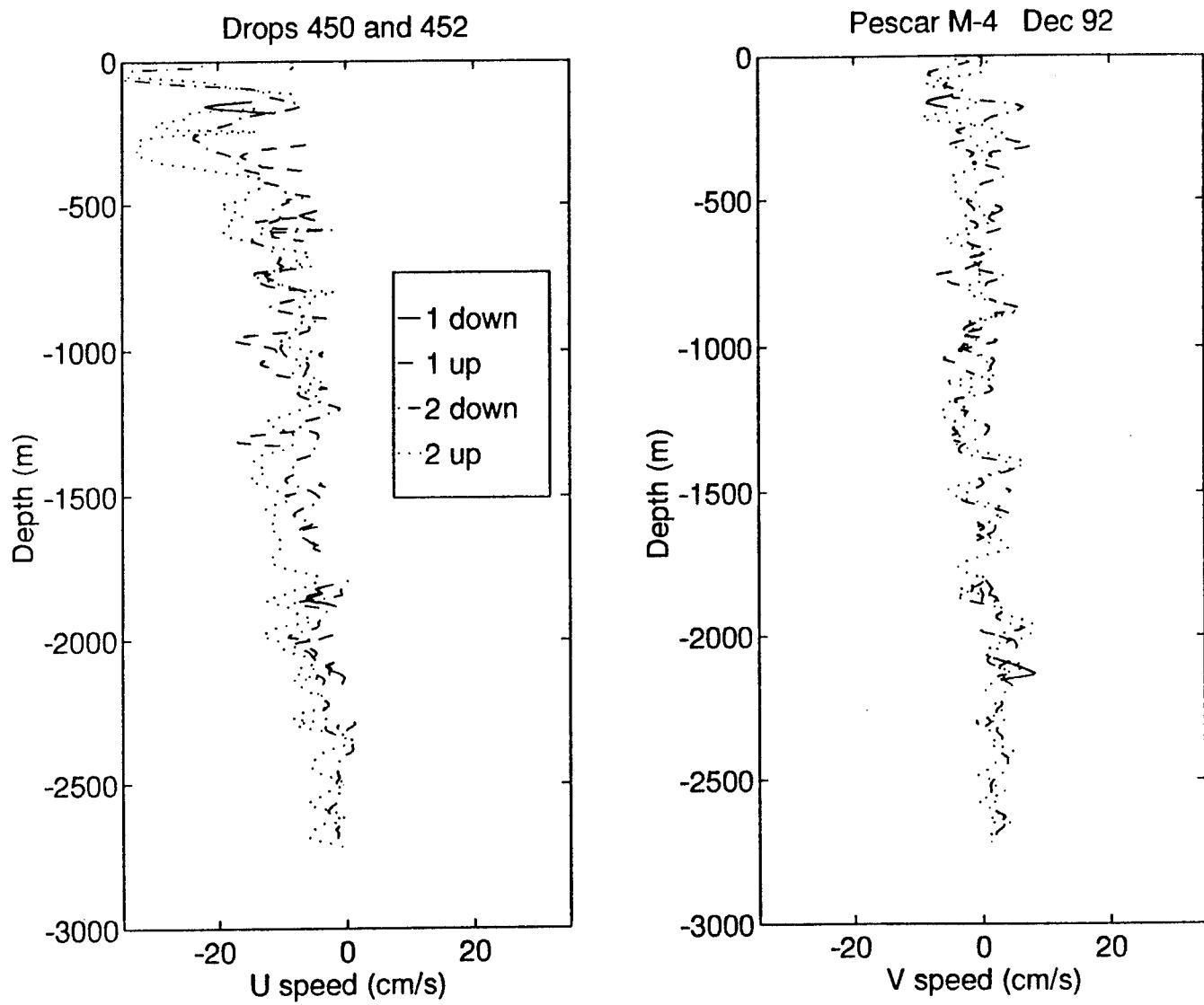


Figure M4-6. Velocity profiles at station M4 for Pegasus drops 450 and 452. Left panel: East-west velocity component. Right panel: North-south velocity component.

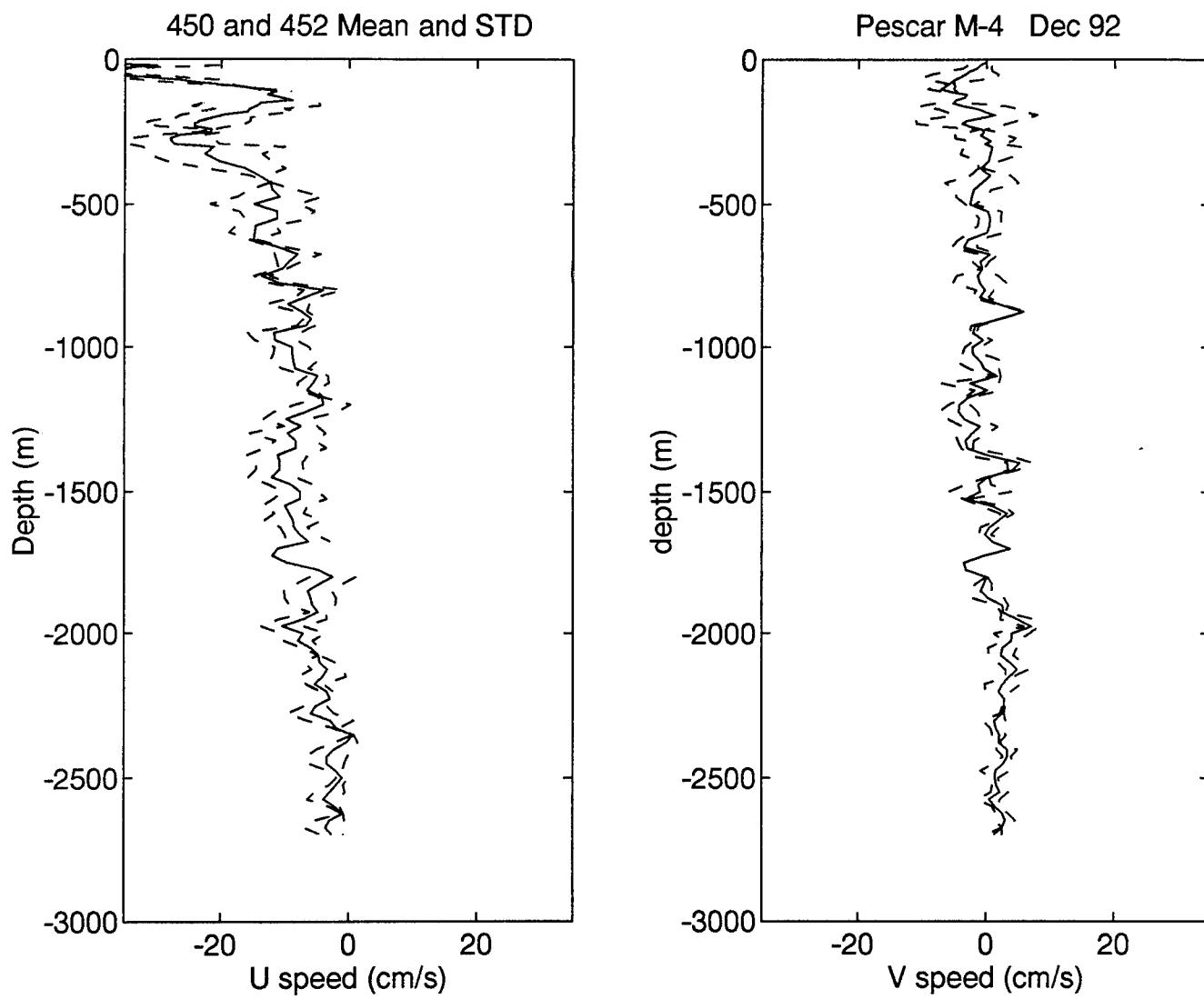
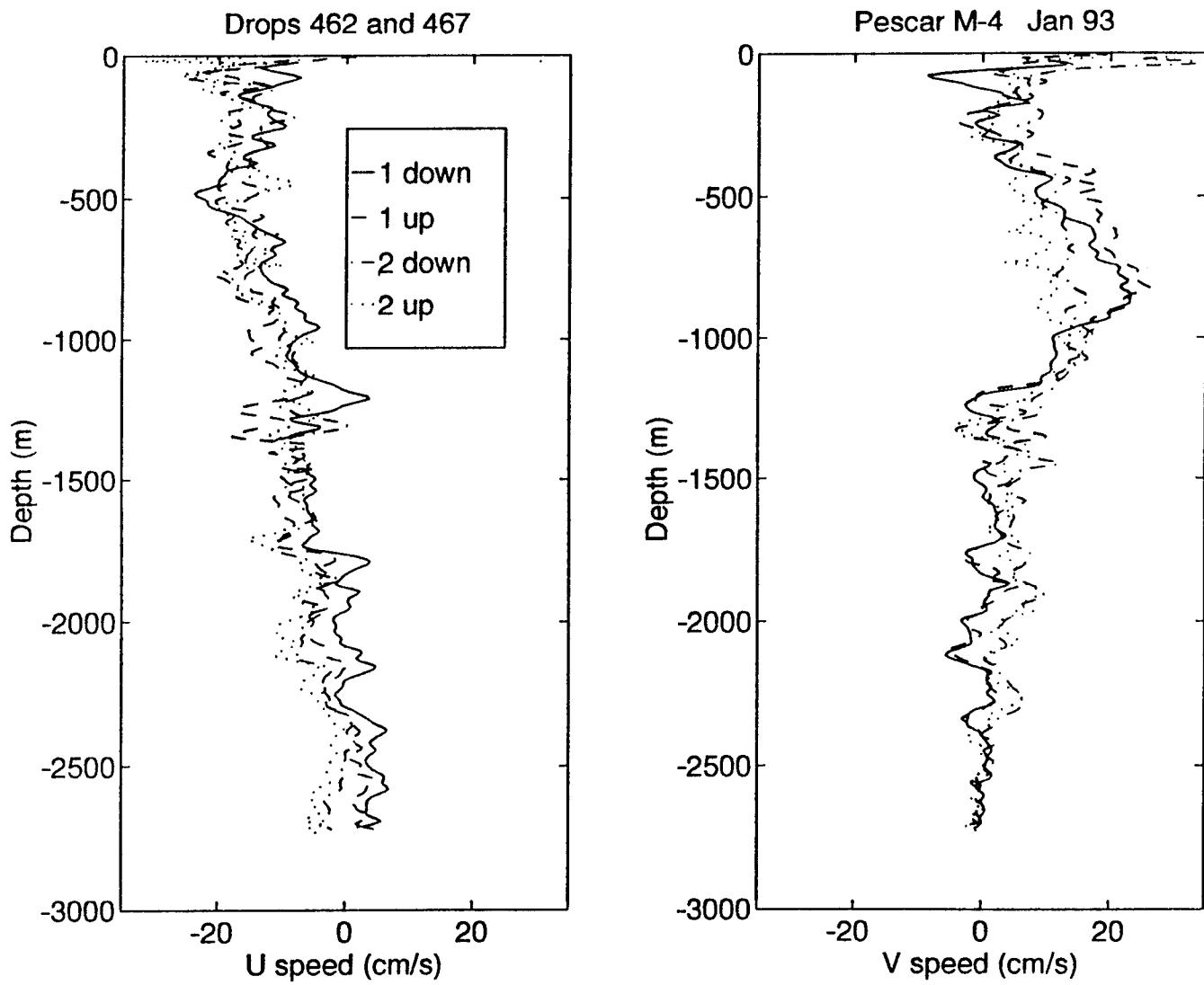


Figure M4-6 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.



**Figure M4-7.** Velocity profiles at station M4 for Pegasus drops 462 and 467. Left panel: East-west velocity component. Right panel: North-south velocity component.

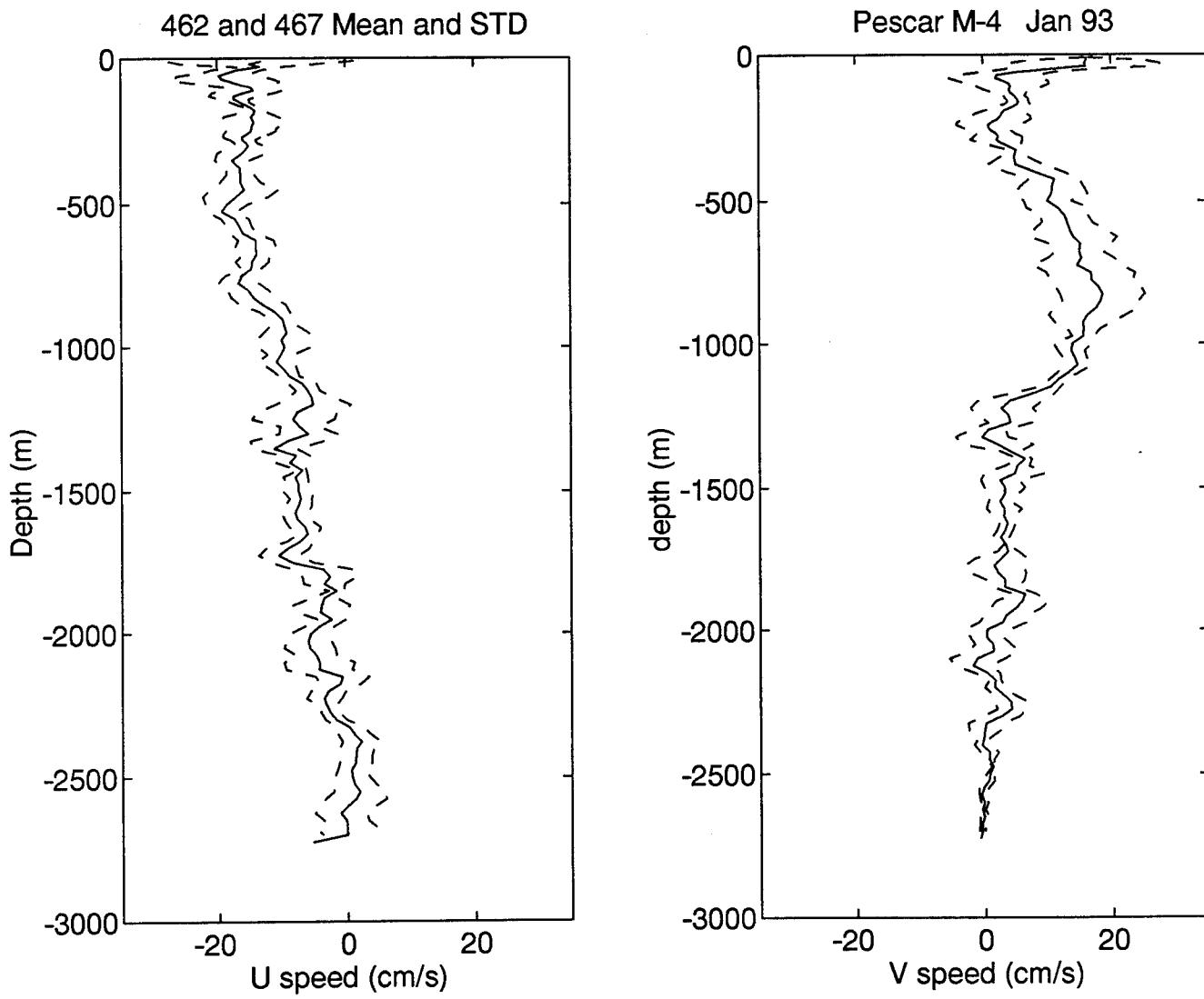


Figure M4-7 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

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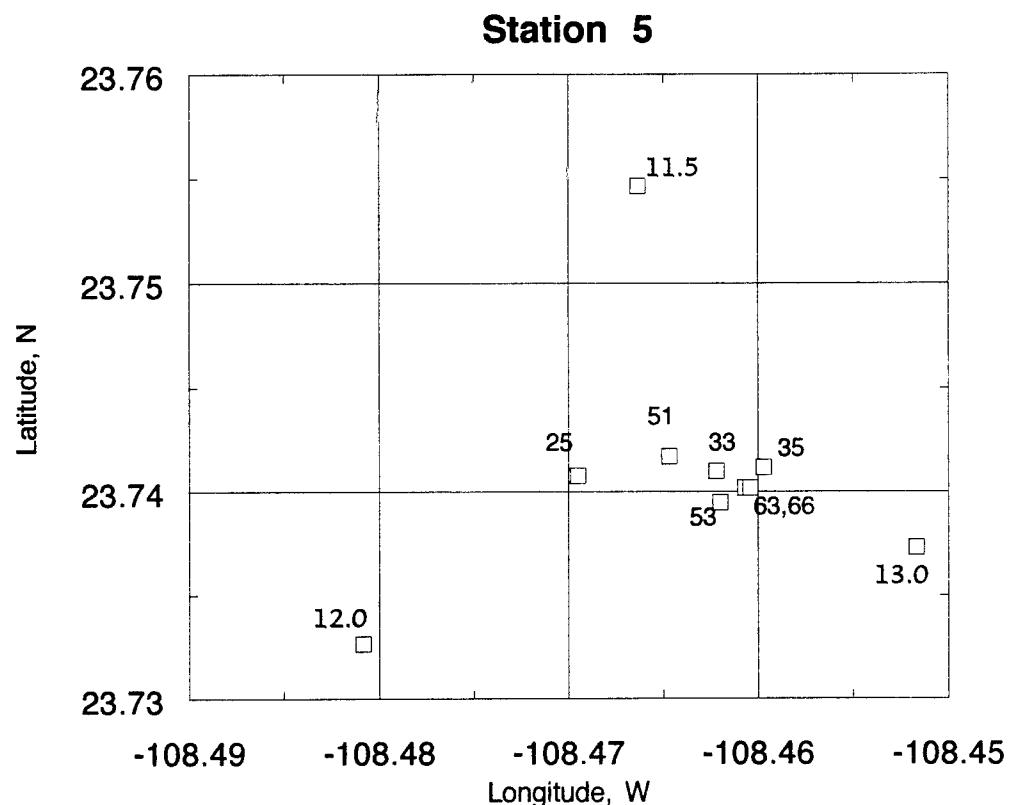


Figure M5-1. Pegasus launch and transponder positions at station M5. Transponders are identified by their reply frequency (11.5, 12.0 and 13.0 kHz) and launch positions are identified by the last two digits of the drop number given in Table 1.

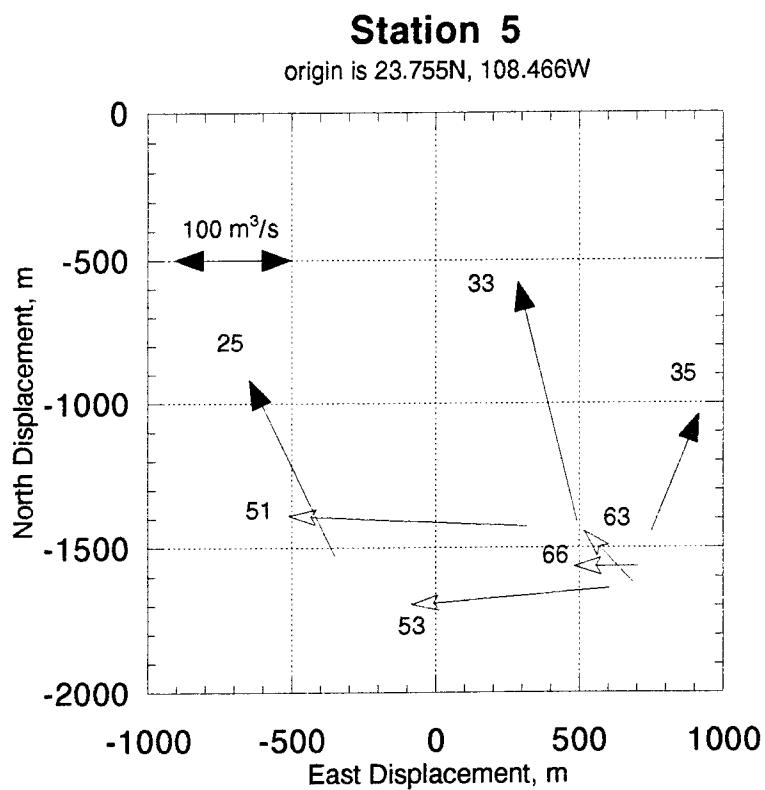


Figure M5-2. Transport measurements at station M5. Vectors connect the launch and surfacing position of Pegasus. The two digit numbers next to the vectors are the last two digits of the drop number given in Table 1. Solid arrow heads indicate observations made during the cruise which began in April 1992 and open arrow heads indicate observations made during the cruise which began in December 1992. Transport values assume a one square meter column of water with a thickness equal to the water depth.

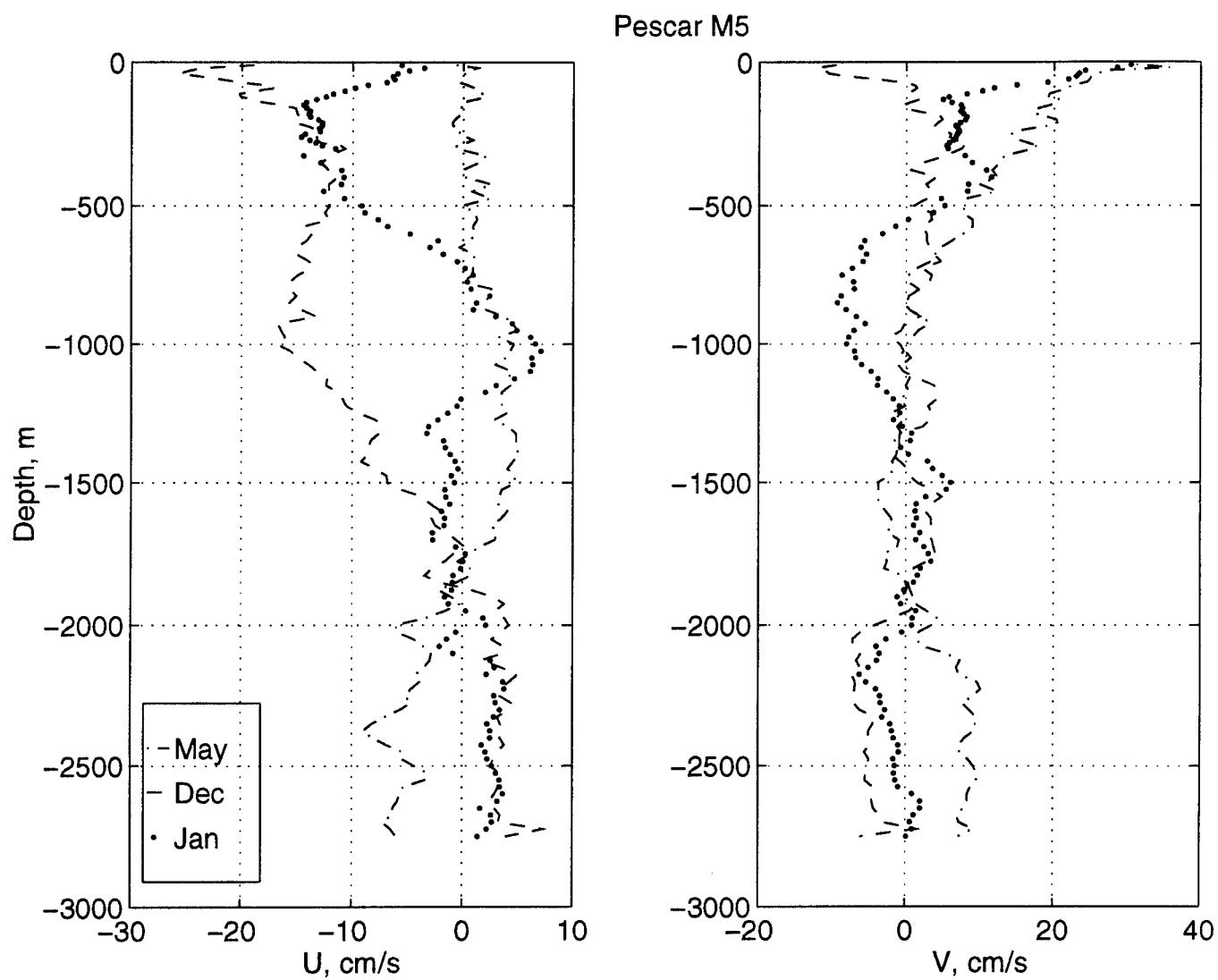


Figure M5-3. Mean velocity profiles at station M5 for each cruise leg. Left panel: East-west velocity component. Right panel: North-south velocity component.

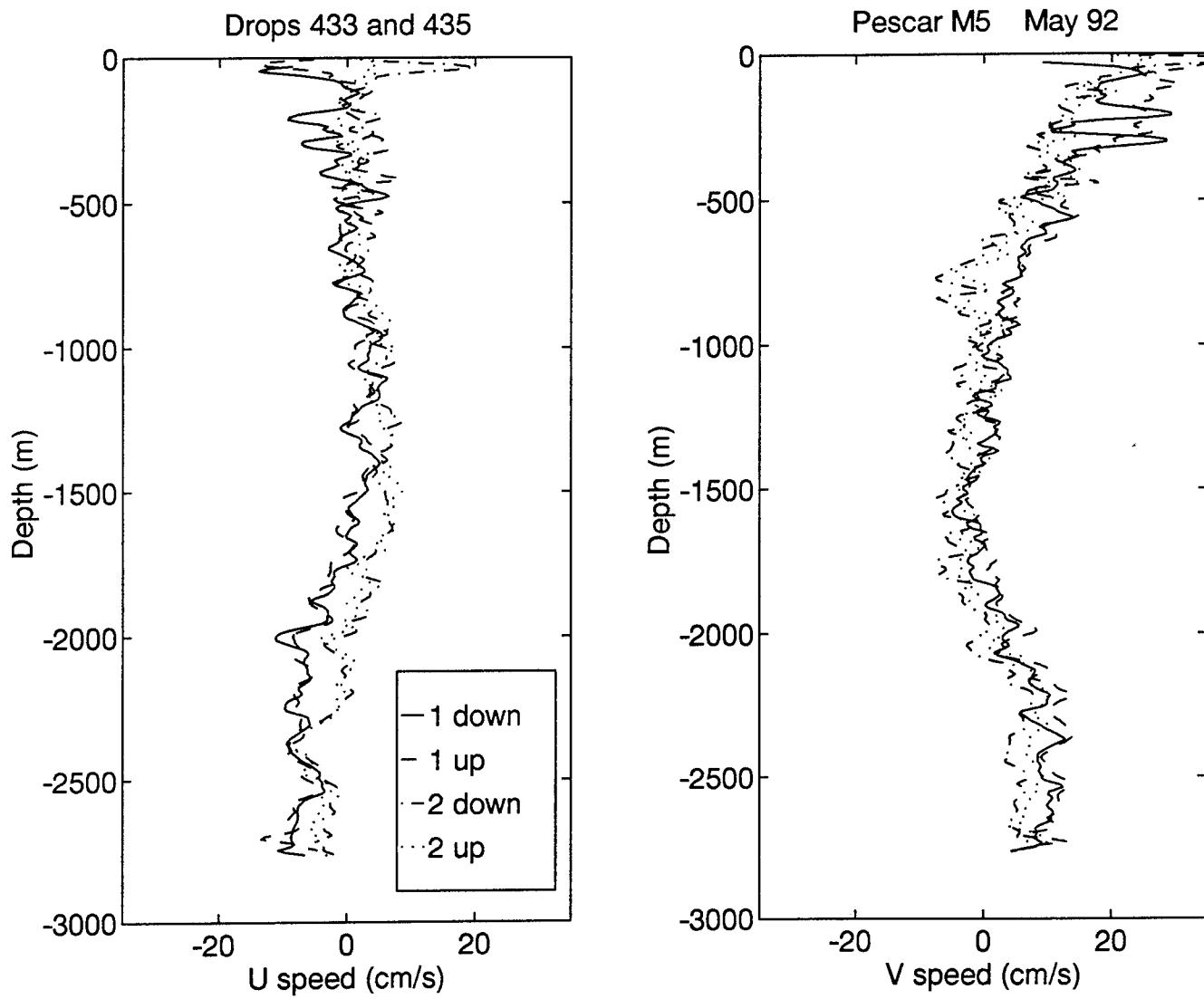


Figure M5-4. Velocity profiles at station M5 for Pegasus drops 433 and 435. Left panel: East-west velocity component. Right panel: North-south velocity component.

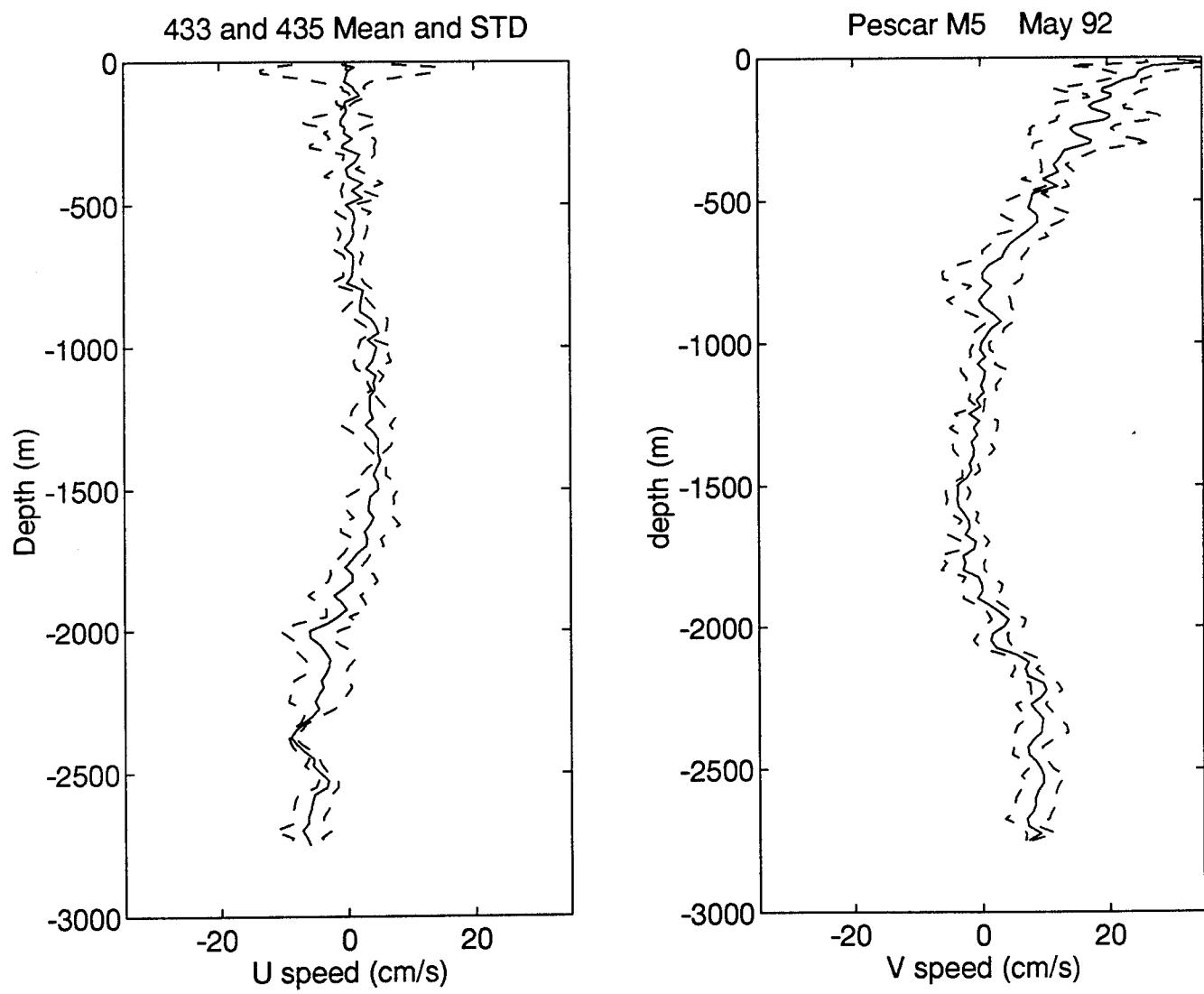


Figure M5-4 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

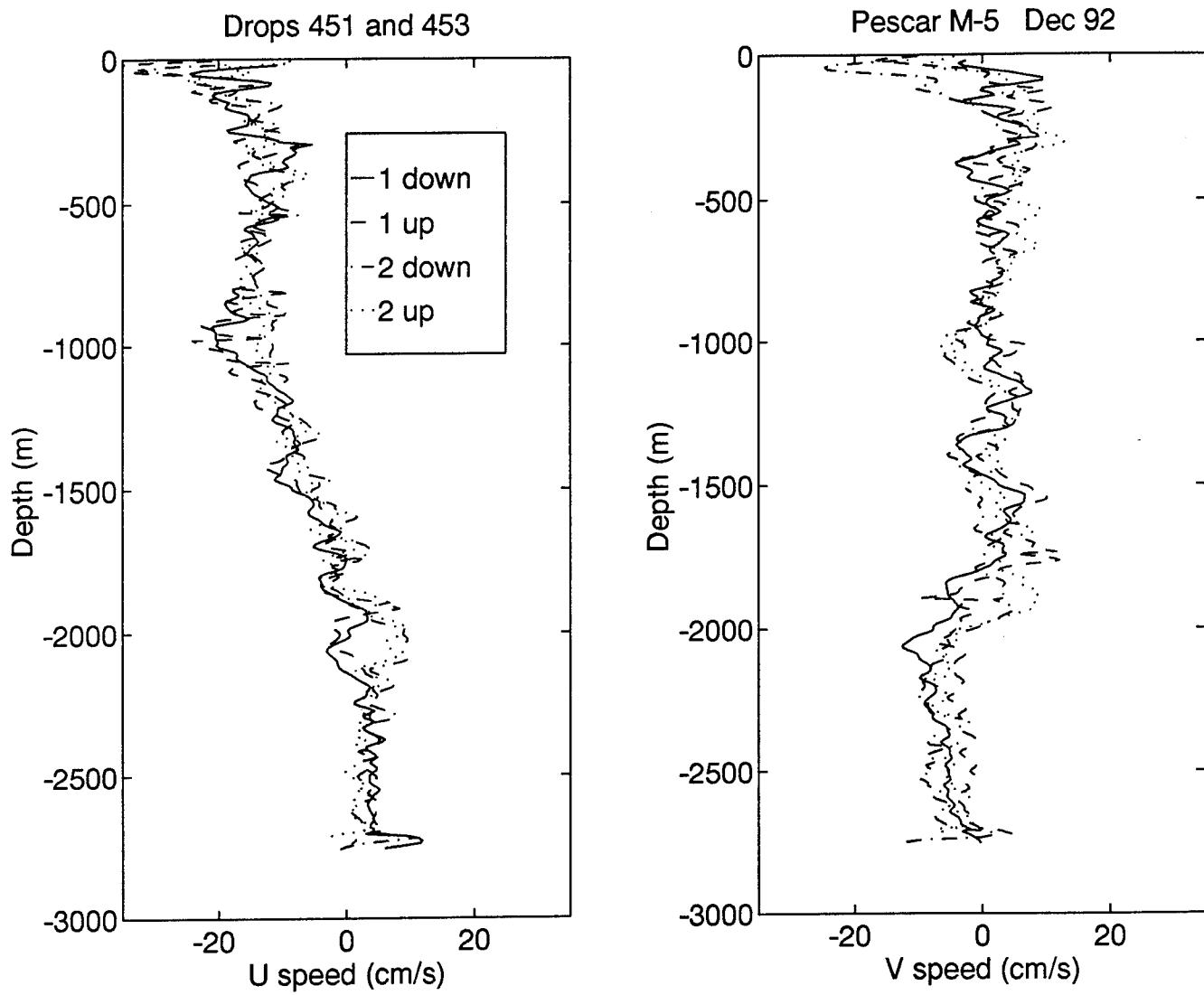


Figure M5-5. Velocity profiles at station M5 for Pegasus drops 451 and 453. Left panel: East-west velocity component. Right panel: North-south velocity component.

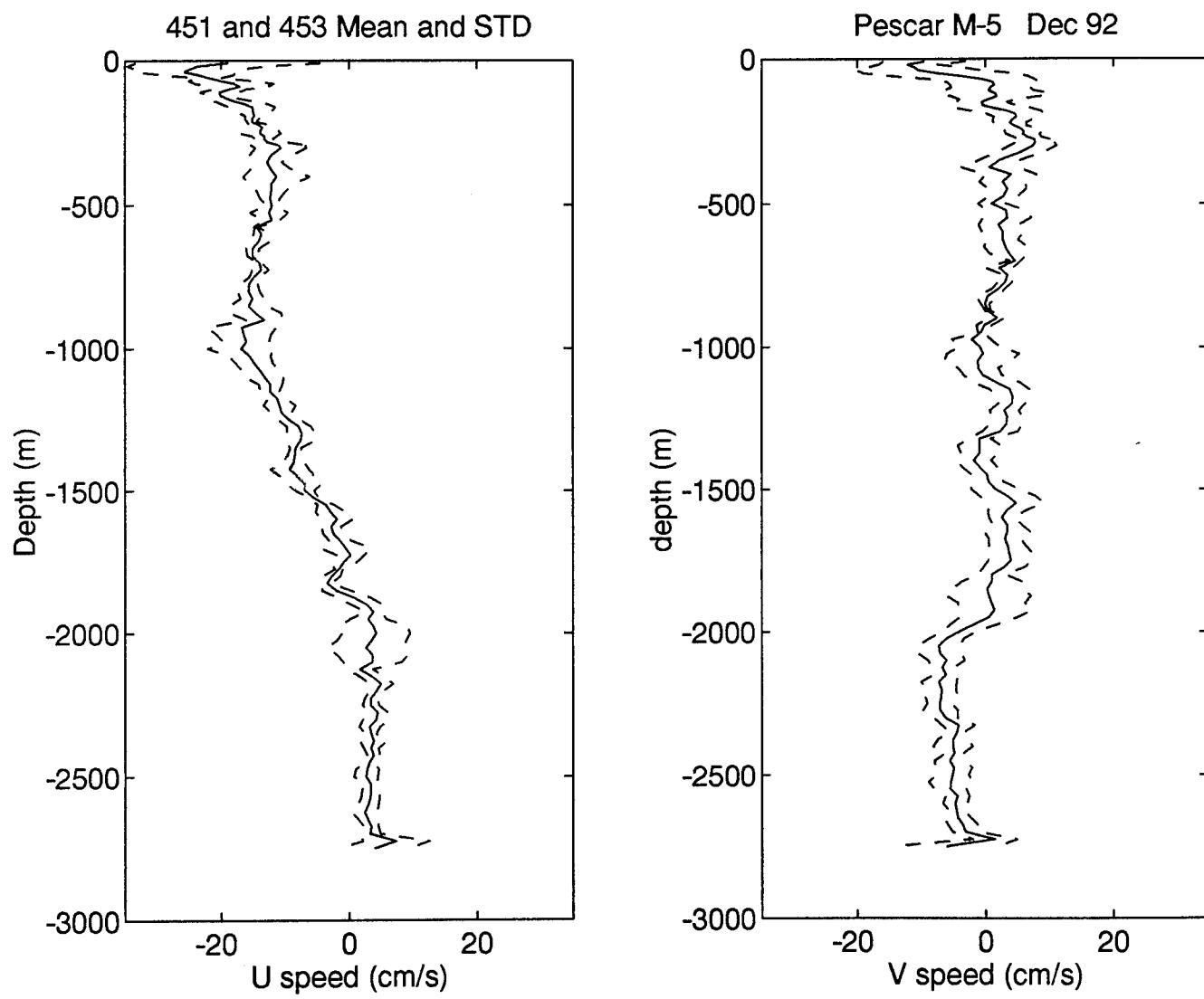


Figure M5-5 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

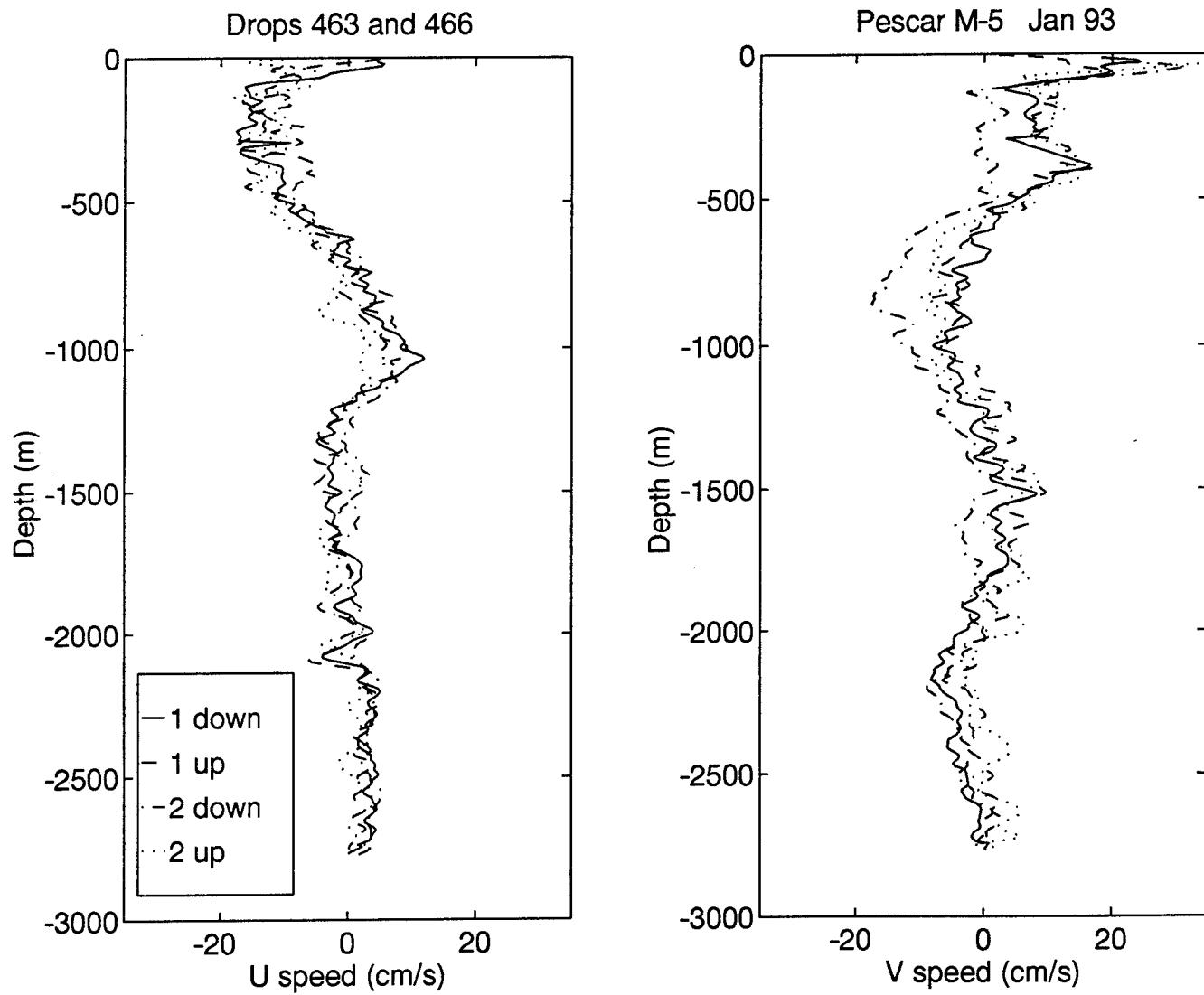


Figure M5-6. Velocity profiles at station M5 for Pegasus drops 463 and 466. Left panel: East-west velocity component. Right panel: North-south velocity component.

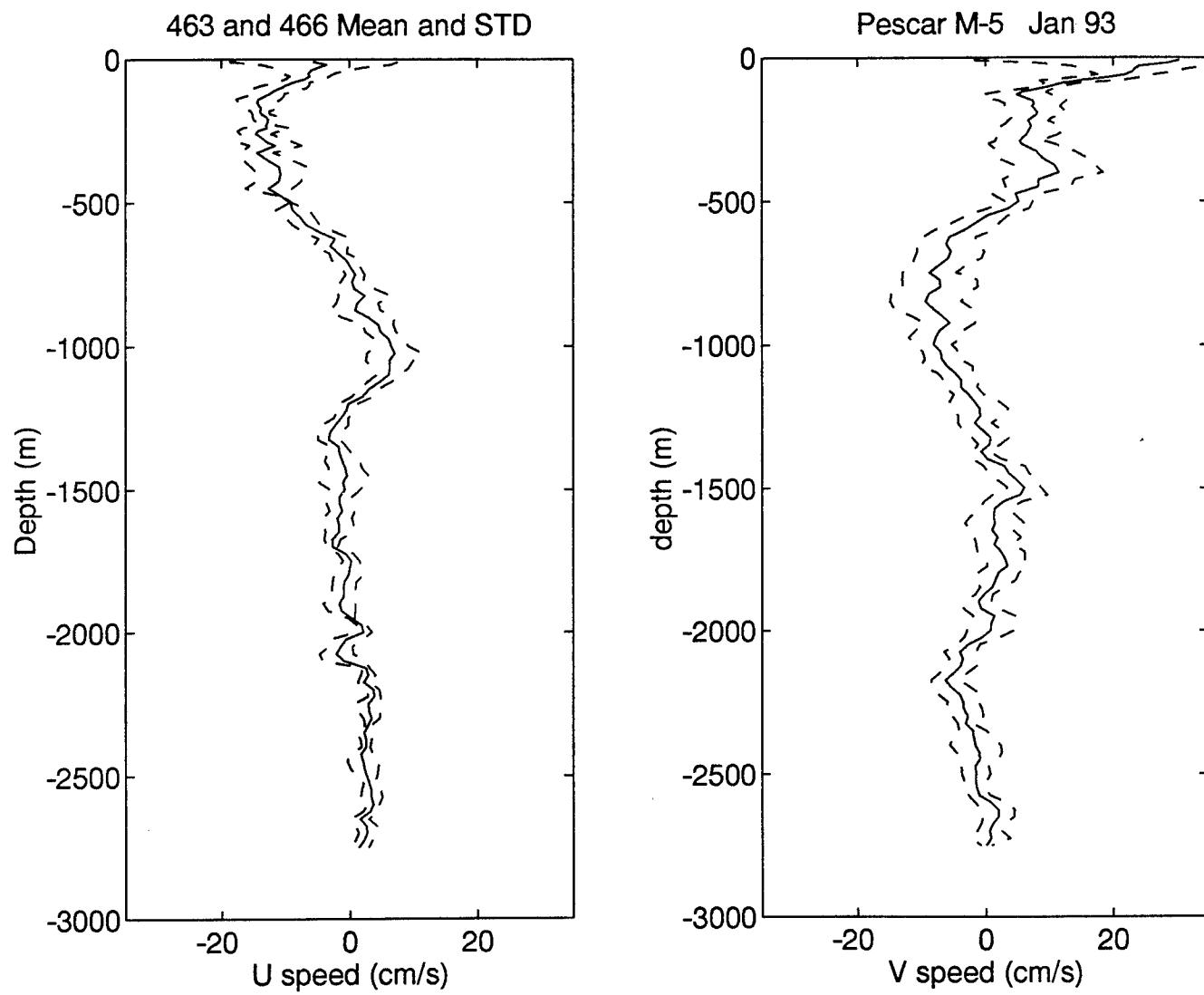


Figure M5-6 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

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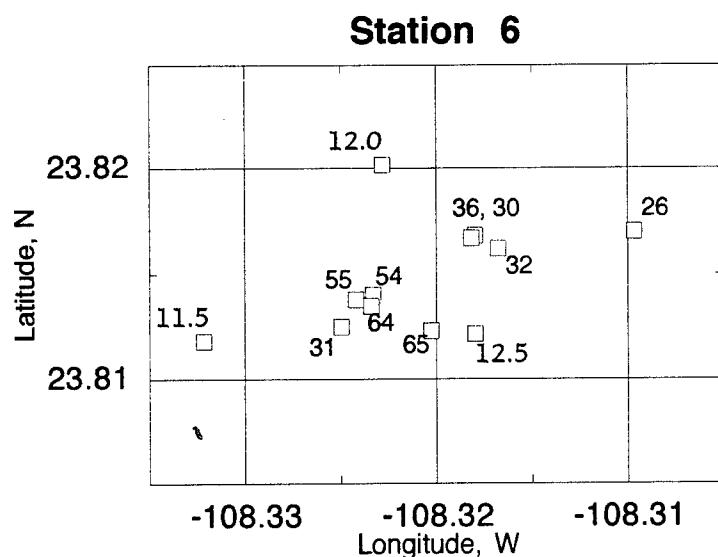


Figure M6-1. Pegasus launch and transponder positions at station M6. Transponders are identified by their reply frequency (11.5, 12.0 and 12.5 kHz) and launch positions are identified by the last two digits of the drop number given in Table 1.

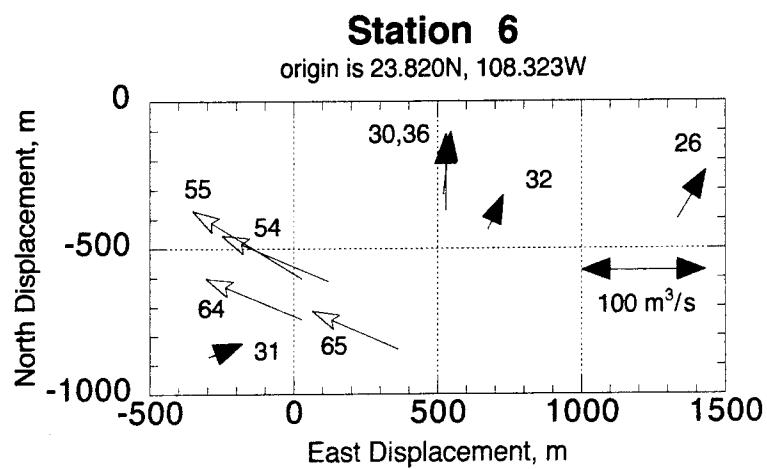


Figure M6-2. Transport measurements at station M6. Vectors connect the launch and surfacing position of Pegasus. The two digit numbers next to the vectors are the last two digits of the drop number given in Table 1. Solid arrow heads indicate observations made during the cruise which began in April 1992 and open arrow heads indicate observations made during the cruise which began in December 1992. Transport values assume a one square meter column of water with a thickness equal to the water depth.

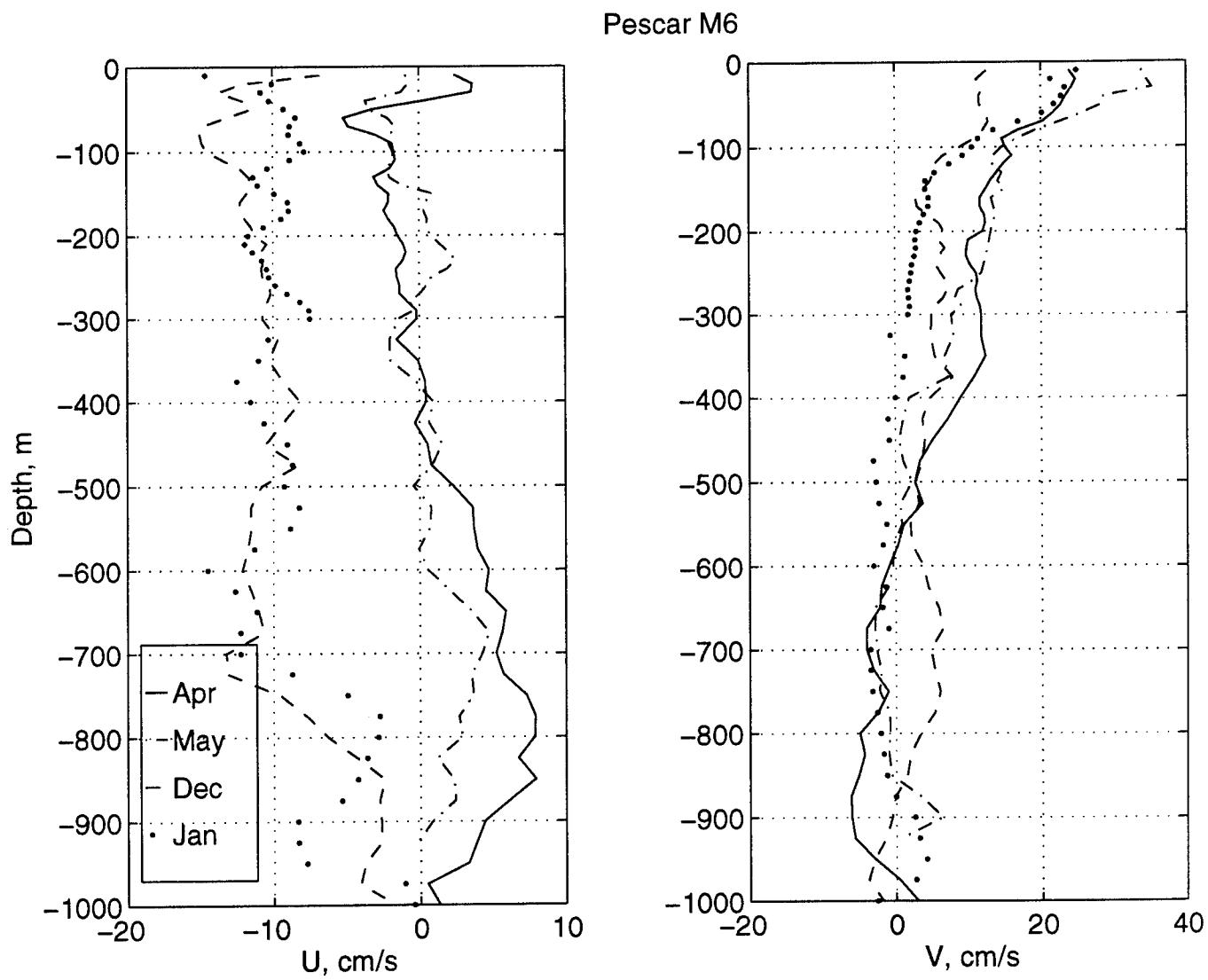


Figure M6-3. Mean velocity profiles at station M6 for each cruise leg. Left panel: East-west velocity component. Right panel: North-south velocity component.

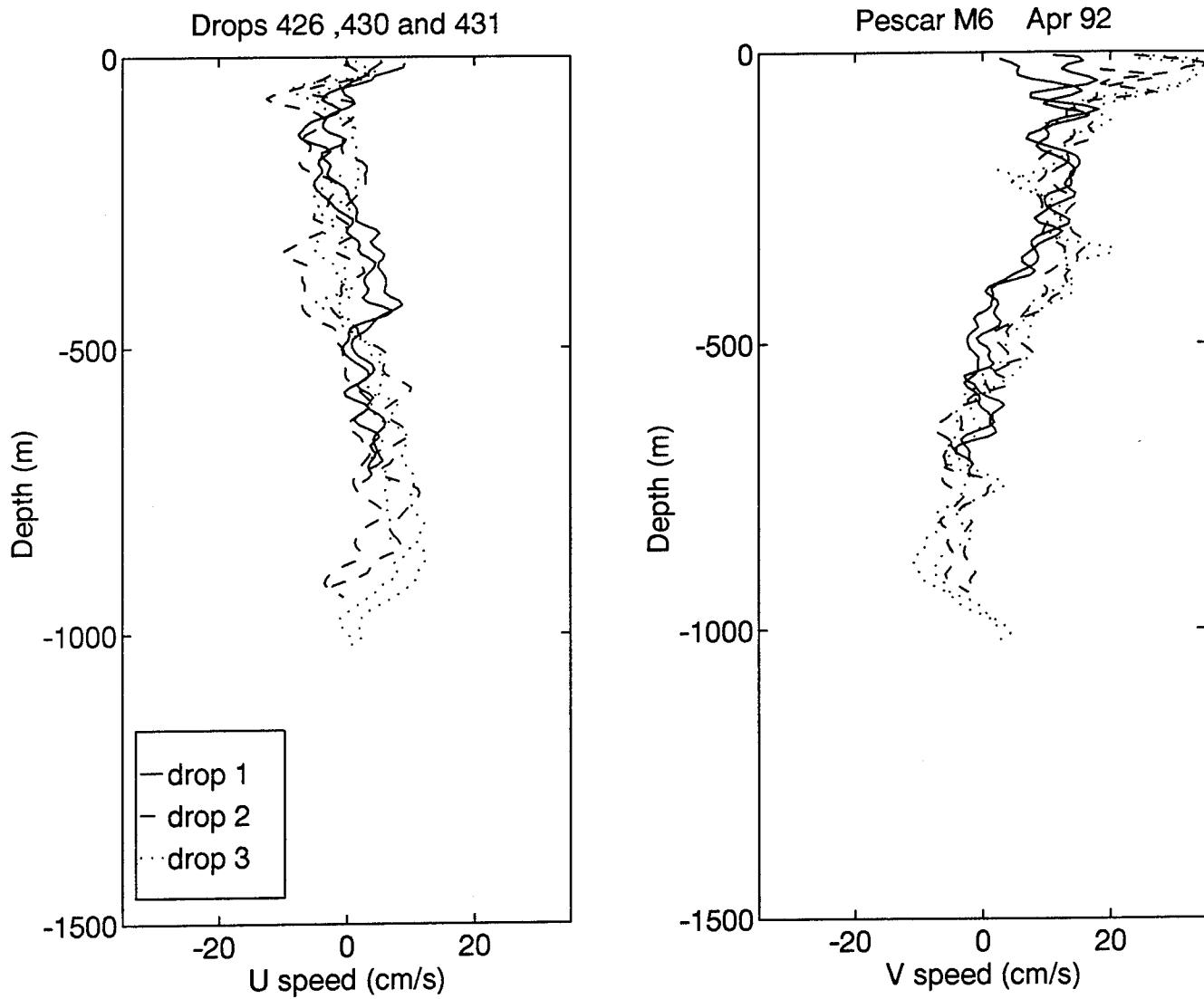


Figure M6-4. Velocity profiles at station M6 for Pegasus drops 426, 430 and 431. Left panel: East-west velocity component. Right panel: North-south velocity component.

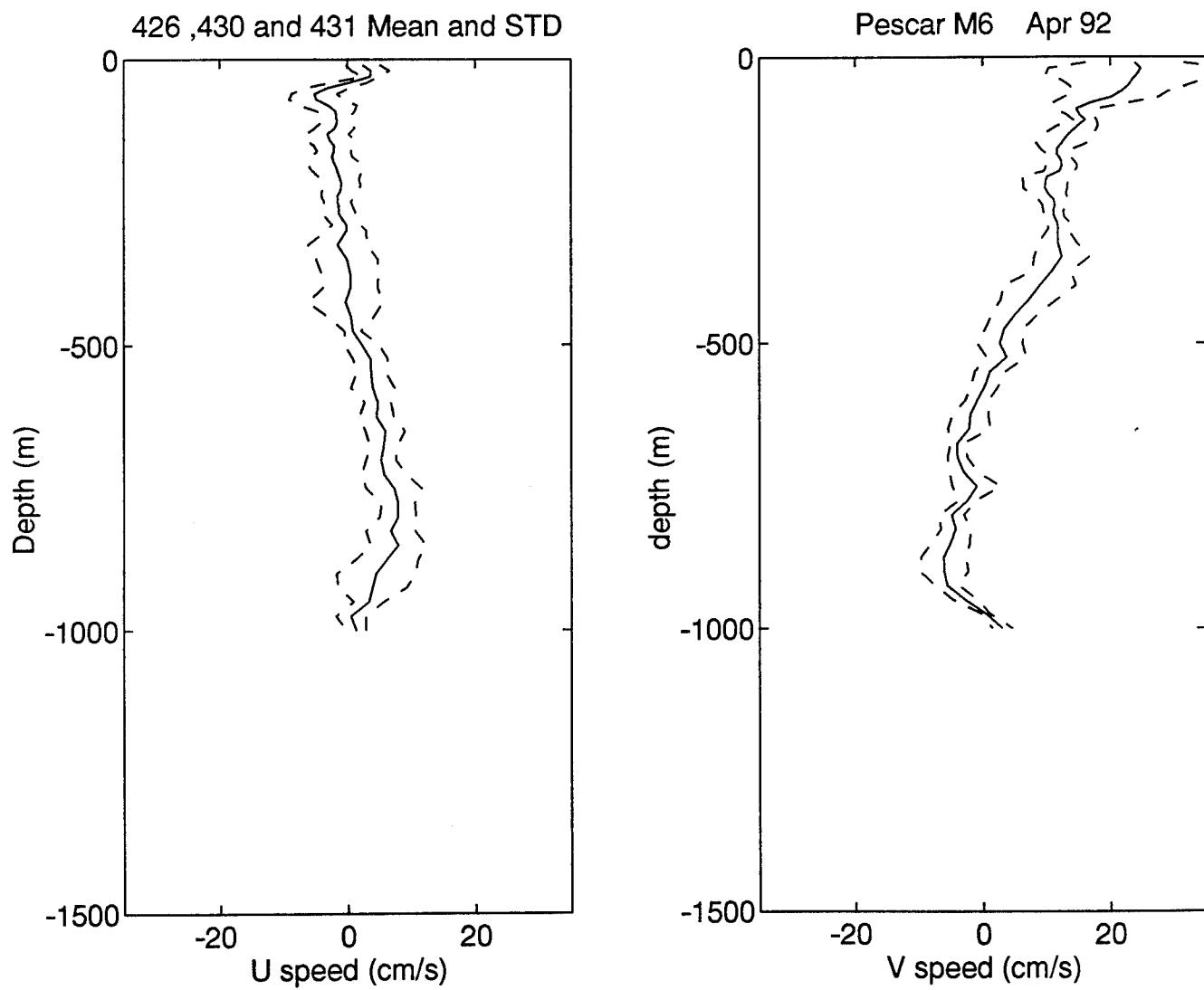


Figure M6-4 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

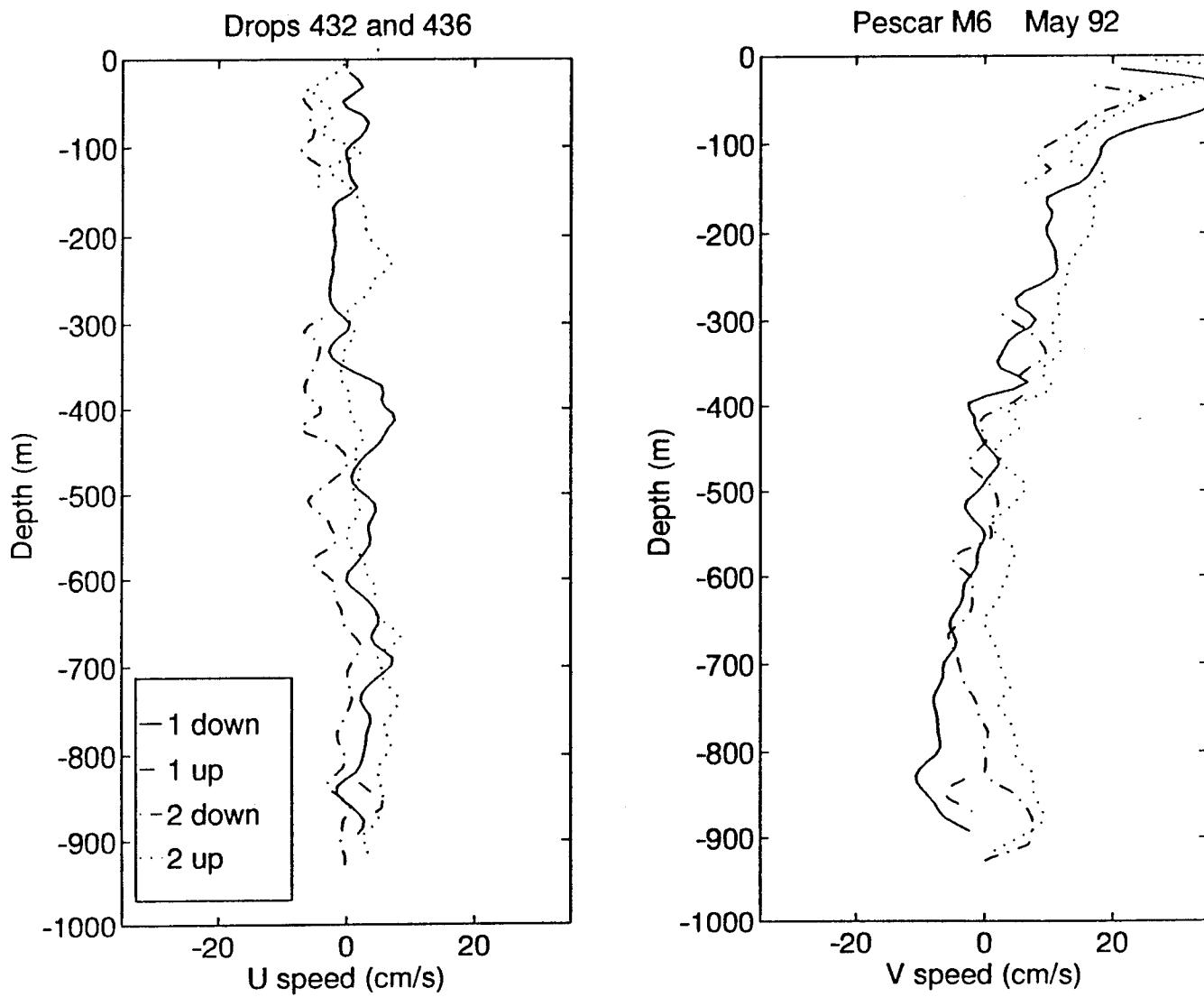


Figure M6-5. Velocity profiles at station M6 for Pegasus drops 432 and 436. Left panel: East-west velocity component. Right panel: North-south velocity component.

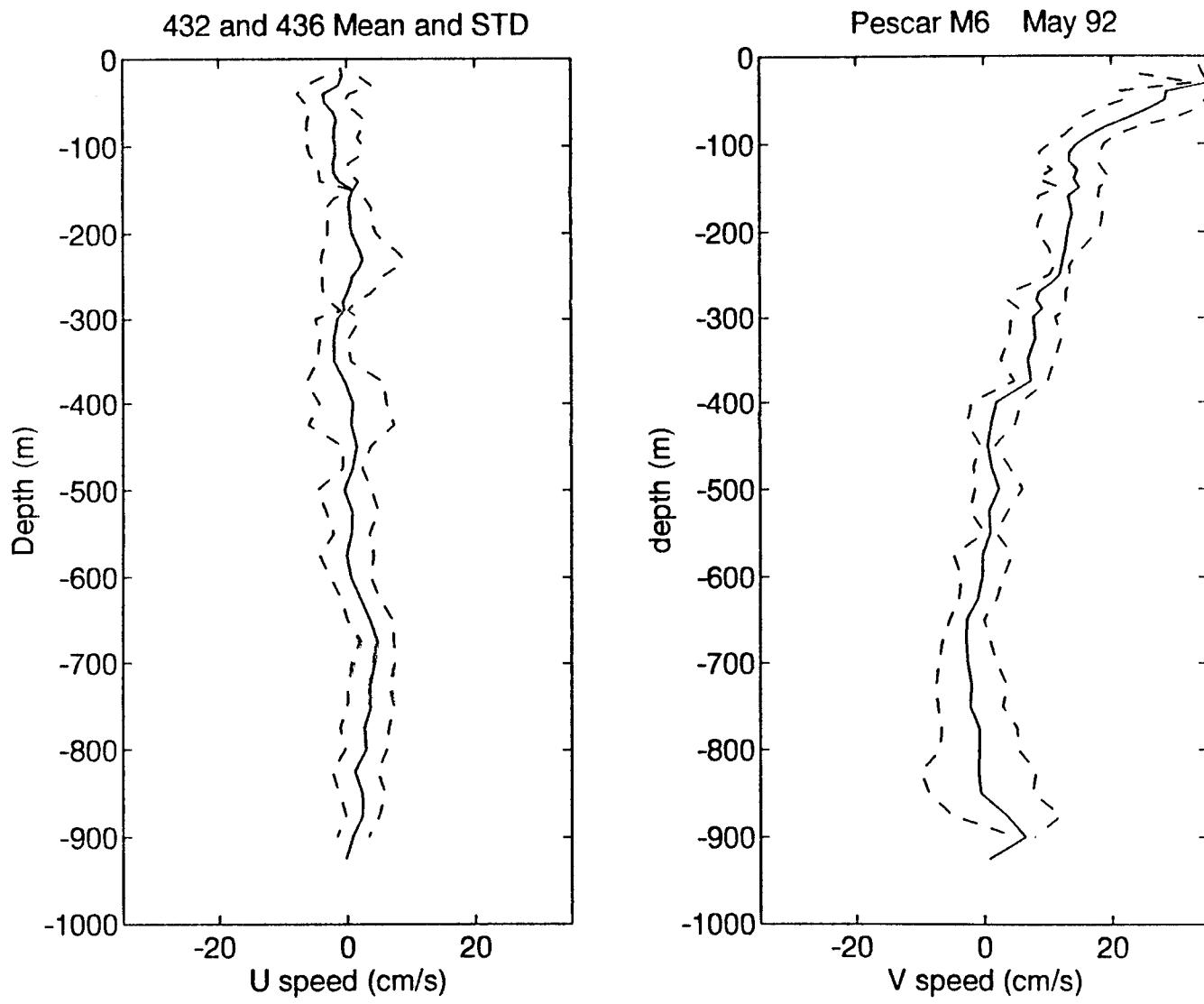


Figure M6-5 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

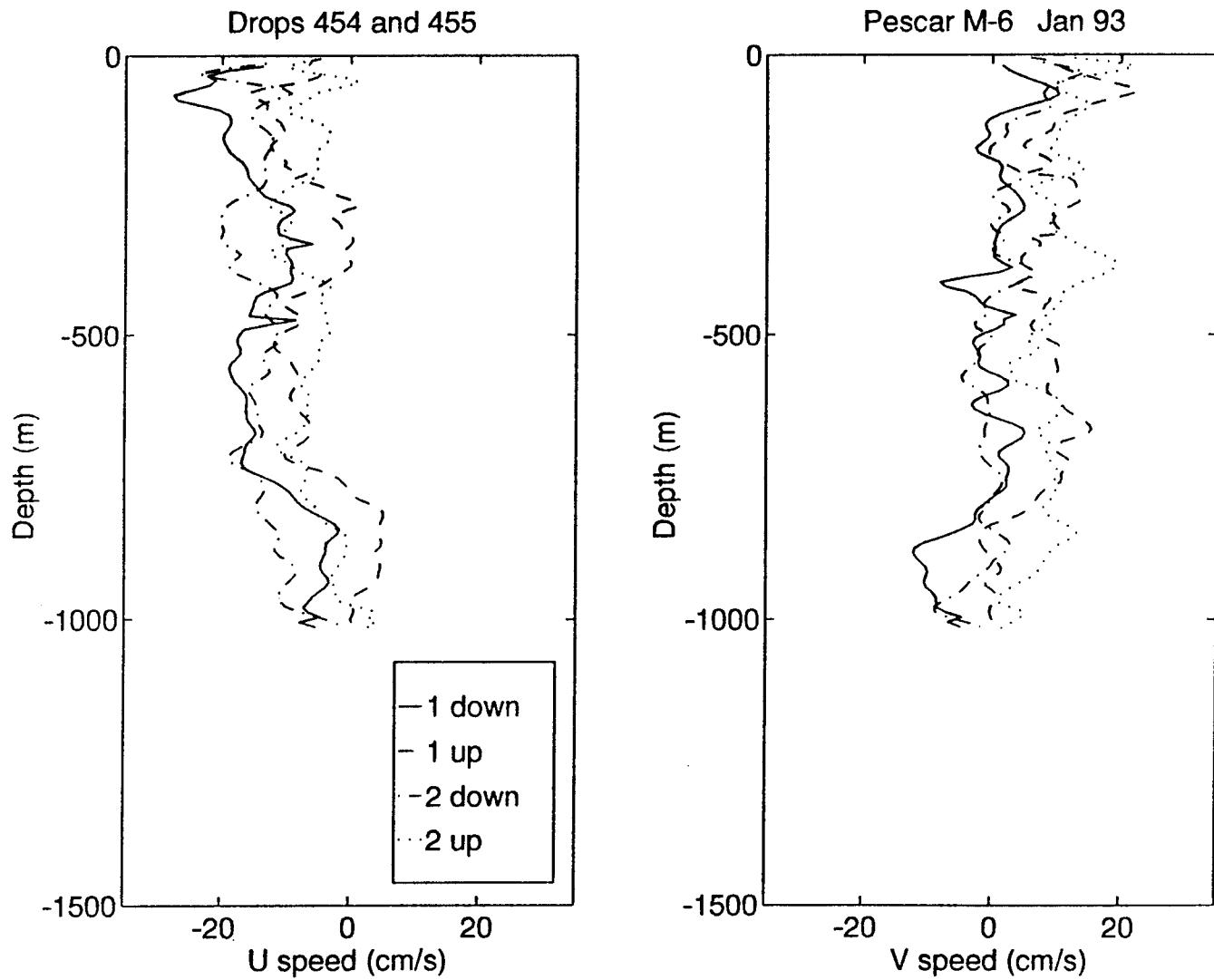


Figure M6-6. Velocity profiles at station M6 for Pegasus drops 454 and 455. Left panel: East-west velocity component. Right panel: North-south velocity component.

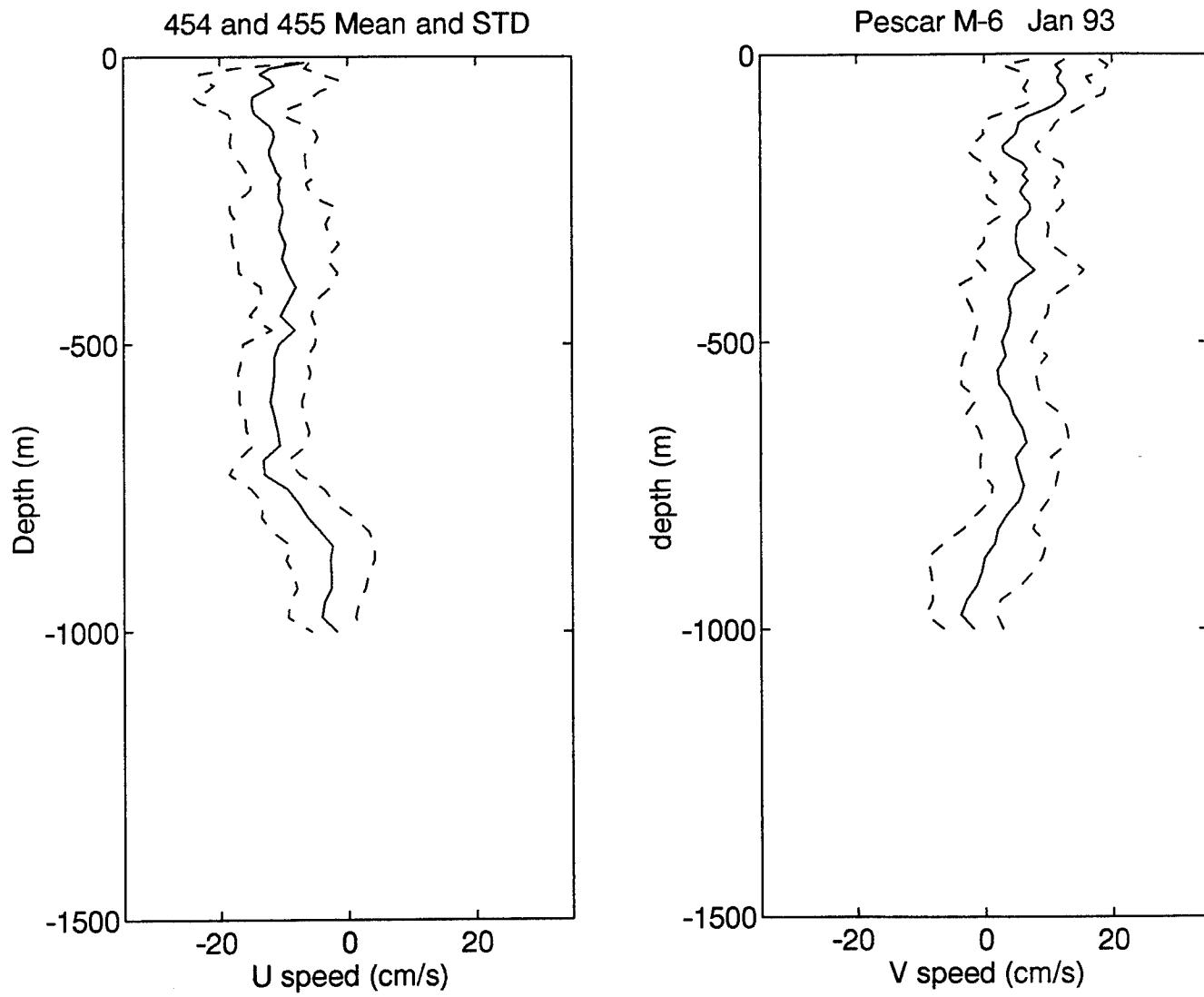


Figure M6-6 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

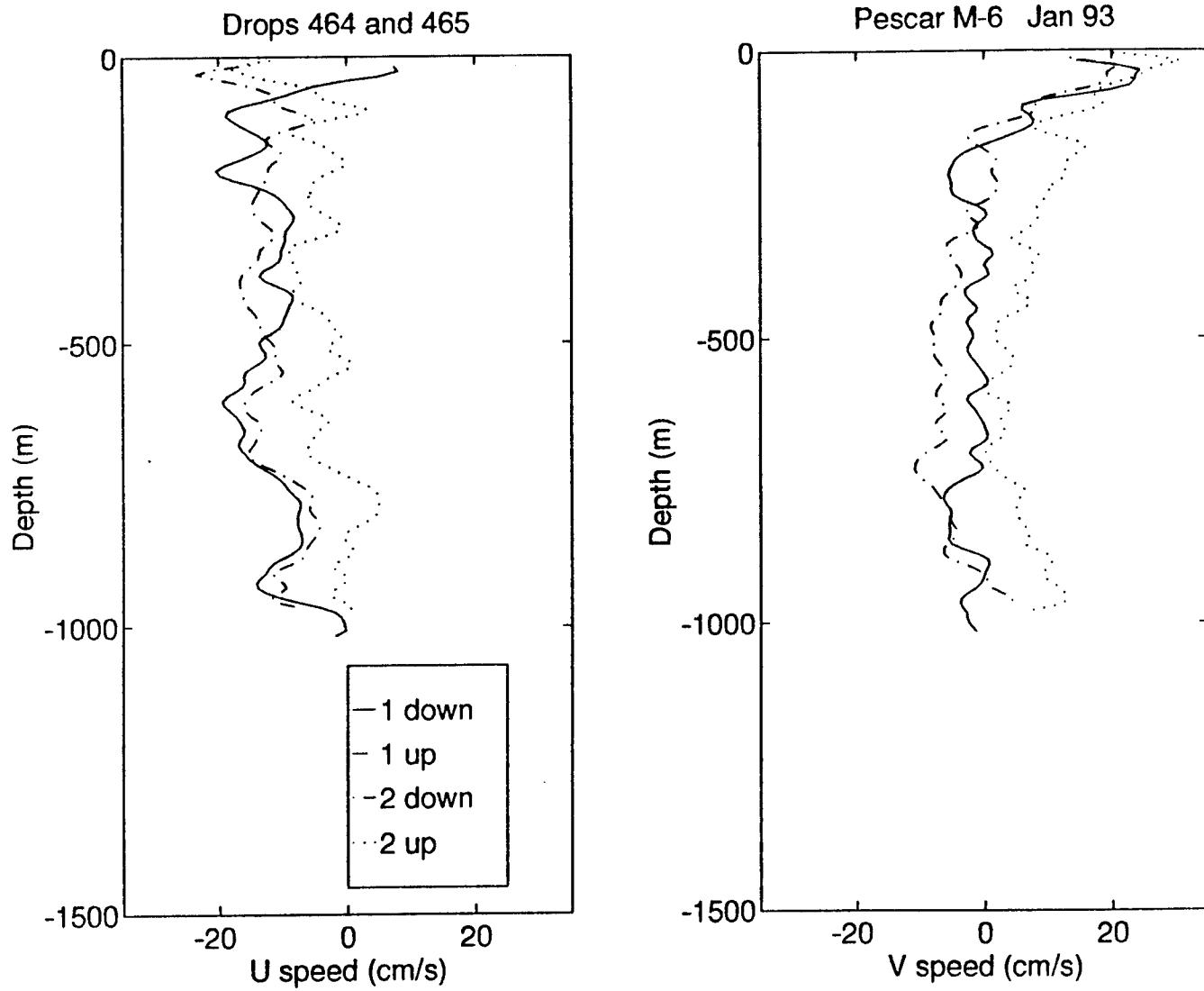


Figure M6-7. Velocity profiles at station M6 for Pegasus drops 464 and 465. Left panel: East-west velocity component. Right panel: North-south velocity component.

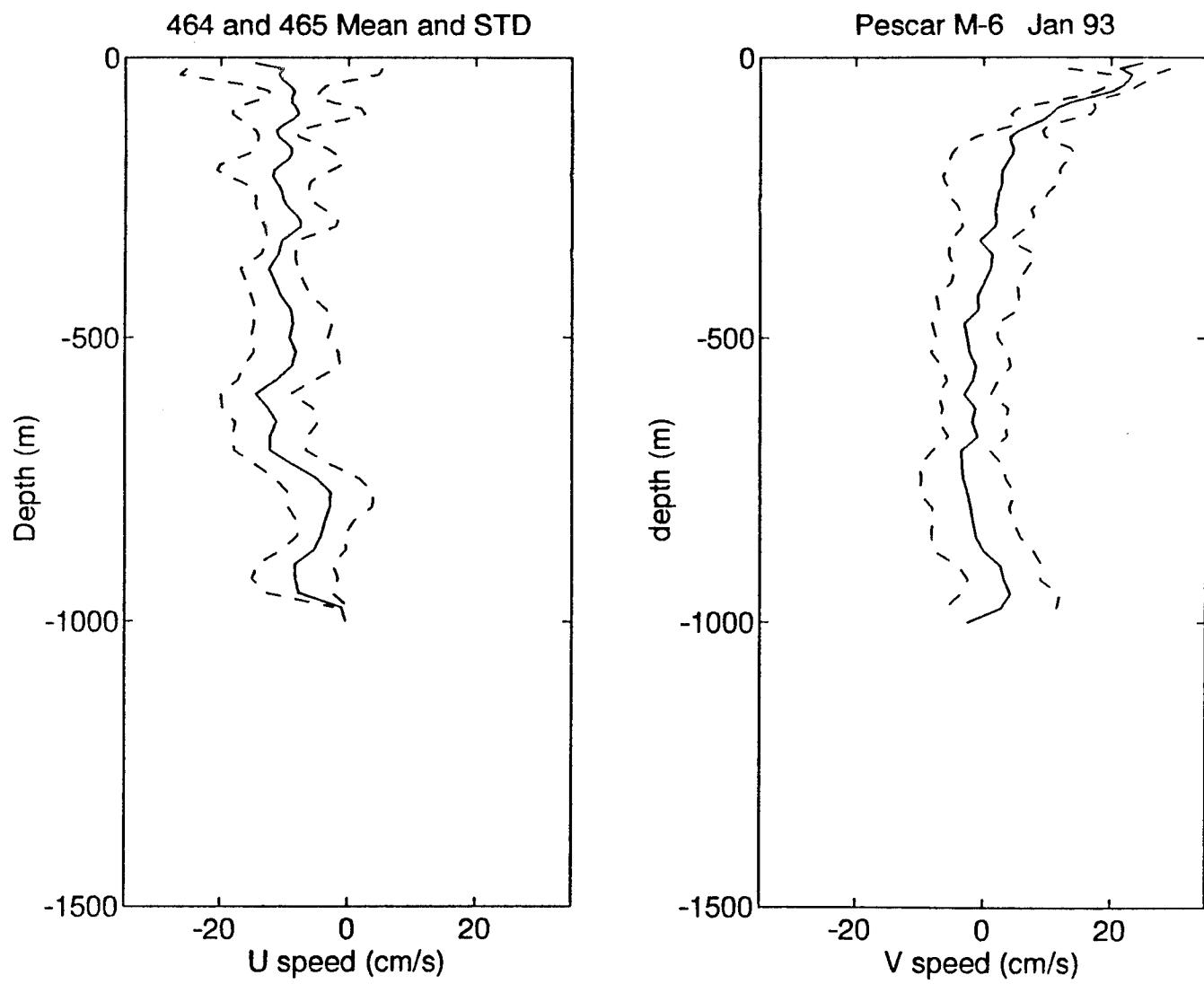


Figure M6-7 (continued). Left panel: Mean and standard deviation for east-west velocity component. Right panel: Mean and standard deviation for north-south component.

Table 2: Cruise Participants

Name	Affiliation
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Curtis A. Collins <sup>a</sup>	Naval Postgraduate School
Newell Garfield	Naval Postgraduate School
Thomas A. Rago	Naval Postgraduate School
Andy Anderson	Naval Postgraduate School
Luis Navarro Olache	Universidad Autonoma de Baja California
Antonio Sanchez Devora	Secretaria de Marina (Ensenada, Mexico)
<b><i>PESCAR-01, Leg 2<sup>c</sup>:</i></b>	
Newell Garfield <sup>a</sup>	Naval Postgraduate School
Thomas A. Rago	Naval Postgraduate School
Andy Anderson	Naval Postgraduate School
Lt. Ross Mitchell, USN	Naval Postgraduate School
Luis Navarro Olache	Universidad Autonoma de Baja California
Antonio Sanchez Devora	Secretaria de Marina (Ensenada, Mexico)
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Curtis A. Collins <sup>a</sup>	Naval Postgraduate School
Paul F. Jessen	Naval Postgraduate School
Andy Anderson	Naval Postgraduate School
Lt. Chip Weddle, USN	Naval Postgraduate School
Lt. Monty Spearman, USN	Naval Postgraduate School
Lt. Paul Fujimura	Naval Postgraduate School
Lt. Rogerio Chumbinho	Naval Postgraduate School
Lt. Chin Li	Naval Postgraduate School
Kathy Rathbun	Moss Landing Marine Laboratory
<b><i>PESCAR-02, Leg 2<sup>e</sup>:</i></b>	
Curtis A. Collins <sup>a</sup>	Naval Postgraduate School
Paul F. Jessen	Naval Postgraduate School
Thomas A. Rago	Naval Postgraduate School
Andy Anderson	Naval Postgraduate School
LCdr. Mike Foster, USN	Naval Postgraduate School
Lt. Pat Cross, USN	Naval Postgraduate School
Antonio Sanchez Devora	Secretaria de Marina (Ensenada, Mexico)
Rafael Blanco Betacourt	Universidad Autonoma de Baja California
Kathy Titley	Naval Postgraduate School
Laurie Ferioli	Naval Postgraduate School
<b><i>PESCAR-02, Leg 3<sup>f</sup>:</i></b>	
Curtis A. Collins <sup>a</sup>	Naval Postgraduate School
Affonso da S. Mascarenhas <sup>a</sup>	Universidad Autonoma de Baja California
Thomas A. Rago	Naval Postgraduate School
Michael Cook	Naval Postgraduate School
Andy Anderson	Naval Postgraduate School
LCdr. John Kent, USN	Naval Postgraduate School
LCdr. Ernie Petrick, USN	Naval Postgraduate School
Lt. Joe Bradley, USN	Naval Postgraduate School
Lt. Rob Haines, USN	Naval Postgraduate School
Lt. Fred Rischmiller, USN	Naval Postgraduate School
Antonio Sanchez Devora	Secretaria de Marina (Ensenada, Mexico)
Monika Bradley	Naval Postgraduate School

<sup>a</sup>Chief Scientist  
<sup>d</sup>16-22 Dec. 1992

<sup>b</sup>21-28 April 1992  
<sup>e</sup>28 Dec. 1992 - 2 Jan. 1993

<sup>c</sup>1-8 May 1992  
<sup>f</sup>3-8 Jan. 1993

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